X-RAY LITHOGRAPHY, P. 33

IEEE
SPECTRUM

DIVERSITY AT WORK

JUNE 1992

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

Newslog

APR 3. Loral Corp.'s Space Systems Division, Palo Alto, Calif., said the **U.S. Department of Defense** had authorized it to import four Hall thrusters for positioning satellites in space from **Fakel Enterprises** of Kaliningrad and the **Research Institute of Applied Mechanics** of Moscow. Loral said it was the first U.S. aerospace company to win Government approval to buy advanced space technology from the former Soviet Union.

APR 9. The **Federal Communications Commission,** Washington, D.C, announced its proposal for introducing high-definition television (HDTV), one that would phase out today's TV transmission technology by the year 2008. Under the plan, each existing broadcast TV station would be paired with an HDTV station for 15 years, letting consumers watch programs on one of today's sets or on the next generation of screens. Thereafter broadcasters would relinquish the old channel for reassignation, and consumers would need to either use HDTV sets or buy decoding devices.

APR 13. AT&T Co. and **Lockheed Corp.,** Calabasas, Calif., said they had formed a joint venture to provide intelligent vehicle highway systems to state and local transportation administrations in the United States and overseas. The venture will allow drivers to pay tolls with a credit card, get up-to-the-minute traffic data, read electronic maps, and summon emergency help.

APR 14. A Federal District Court judge in San Francisco dismissed most of Cupertino, Calif.-based **Apple Computer Inc.'s** copyright lawsuit against **Microsoft Corp.,** Redmond, Wash., and **Hewlett-Packard Co.,** Palo Alto, Calif. Apple had argued that Microsoft's Windows and HP's New Wave programs infringed upon its Macintosh PC screen displays. The judge ruled the display elements at issue were either not unique or covered by a 1985 licensing agreement with Microsoft. [On May 12, the judge agreed to reconsider his ruling.]

APR 15. Cable & Wireless PLC, London, said it had formed a joint venture with Russia's Intertelecom to modernize, develop, and operate long-distance and international communications networks in Moscow, St. Petersburg, and large towns near Moscow and Russia's main Samotlor oilfield in west Siberia.

APR 16. AT&T Co. said it had signed an agreement with **Vietnam's state telecommunications company** in Hanoi to reopen telecommunications links severed since the end of the Vietnam War.

APR 16. Researchers at **General Electric Co.,** Fairfield, Conn., said they had developed "self-healing" computer chips that catch and correct errors caused by faulty circuit elements without halting data processing. The technology increases the chip size only slightly.

APR 16. Ing. C. Olivetti, Groupe Bull, and **Siemens-Nixdorf**—Europe's three leading computer makers—said they would cooperate in developing large information networks around common systems and software for public sector bodies in the European Community.

APR 20. South Korea's **Hyundai Electronics Industries Co.** said it will relocate its PC division, from management on down, from Seoul to San Jose, Calif. The unit's move to Silicon Valley will improve the company's responsiveness to rapidly changing market conditions.

APR 22. IBM Corp. and nine large cellular telephone companies, including **McCaw Cellular Communications Inc.,** Kirkland, Wash., and **GTE Corp.,** Stamford, Conn., announced that they were developing methods to send data like facsimiles and electronic mail over the existing cellular telephone network. The new service will broadcast via radio antennas at 19.2 kb/s, or twice the speed of the fastest fax machines today.

APR 23. Fujitsu Ltd., Tokyo, and South Korea's **Samsung Group,** Seoul, said they had signed a semiconductor cross-licensing agreement allowing Samsung to use Fujitsu's advanced technology. It is the first publicly confirmed semiconductor pact between Japan and Korea.

APR 23. Philips Electronics NV, the Netherlands, and **SGS-Thomson Microelectronics NV,** the Franco-Italian chip maker, said they had finalized an accord to develop advanced ICs for use in such products as high-definition television receivers, mobile phones, and integrated-services digital networks.

APR 23. Researchers led by astrophysicist George Smoot at **Lawrence Berkeley Laboratory** in California said that, using satellite data, they had discovered faint temperature fluctuations in the microwave background radiation—no more than a hundred-thousandth of a degree—that represent primeval variations in the universe's topography just 300 000 years after the Big Bang. As the universe expanded, the scientists believe, the initial tiny irregularities coalesced into stars and galaxies.

APR 27. Compaq Computer Corp., Houston, Texas, announced it was withdrawing from the **Advanced Computing Environment (ACE),** a consortium of 200 companies trying to set a new industry standard for advanced reduced-instruction-set computing architecture (ARC). Compaq, once an ACE leader, had shifted its focus toward low-end, cost-competitive systems. Its withdrawal prompted some debate over the ACE group's future.

MAY 4. AT&T Co. said it would use video technology and equipment to deliver new entertainment offerings, including a pay-per-view service and video on demand, to consumers' television receivers. The AT&T system would deliver TV signals via satellite through **ComStream Corp.,** San Diego, Calif. **News Datacom Inc.** would provide systems to process customer requests for programs.

MAY 7. IBM Corp. announced it would sell its remaining 50 percent stake in **Rolm Co.,** Rolm Corp.'s marketing and service operation, to **Siemens AG,** Munich. Siemens had purchased Rolm's manufacturing and development operation, Rolm Systems, in 1989 for US $1 billion. Siemens will consolidate the two companies and headquarter the new unit in Santa Clara, Calif.

MAY 7. Industry executives said that **IBM Corp.** and **Time Warner Corp.,** New York City, are discussing whether IBM should buy a $500 million stake in Time Warner Entertainment. The move would be part of a plan by the companies to merge IBM's computer technology with Time Warner's movies, television shows, and cable TV system.

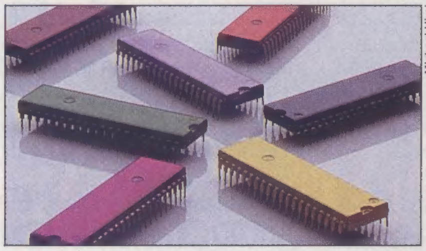
Preview:

JUNE 8–9. The **Eighth Annual Convocation of Professional Engineering Societies and the National Academy of Engineering** is to be held in Washington, D.C. The heads of major engineering groups are to discuss engineering education, engineering cooperation with Eastern Europe, and unity among the U.S. engineering community.

COORDINATOR: Sally Cahur

JUNE 1992 Volume 29 Number 6

IEEE SPECTRUM



Michael Hirst

Gene Dzaman

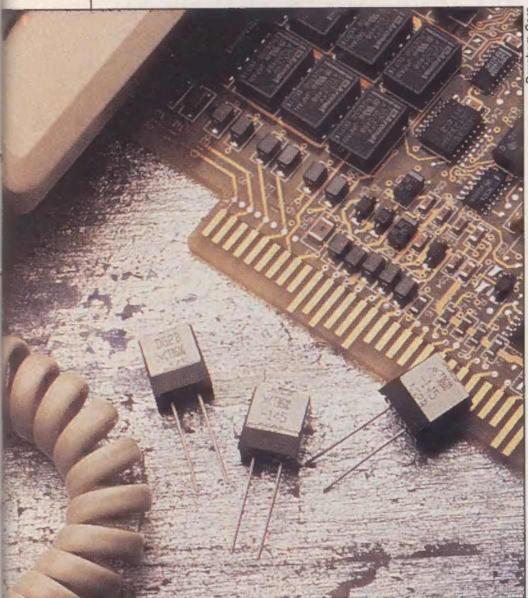
The second-generation Kumakhov lens, developed by the Institute for Roentgen Optical Systems in Moscow, consists of several hundred thousand glass capillaries, which conduct X-rays from a point source. The lens is one of a group of promising X-ray optical devices and sources that could soon lead to the development of an alternative to lithographic systems based on costly, unwieldy synchrotrons.

AT&T Microelectronics

MATERIALS

By KARL F. SCHOCH and HOWARD E. SAUNDERS

Conducting polymers are at the heart of a Polyswitch, a device from Raychem Corp., Menlo Park, Calif., that protects telephones and switching equipment against overcurrent. Excessive circuit current causes a conducting polymer core—plastic embedded with fragments of conducting material—to overheat and expand, thereby breaking the circuit. Many more applications are identified in the article.

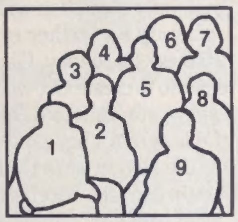


SPECTRAL LINES

By DONALD CHRISTIANSEN

Innovations in the electrical engineering curriculum are being driven by the changing nature of the profession; the needs of employers and the preparation and motivation of students are shifting. Students may conclude that "this is not what I thought electrical engineering would be."

Cover: AT&T's 800-service project team epitomizes diversity. (1) Louis Taff, adjunct services systems engineer; (2) Randall Nelson, network systems manager; (3) Mary Currao, product development team leader; (4) Ruth Diaz de León de Pagay, operations systems engineer; (5) Kenneth Gibbons, district manager, 800 services; (6) Elizabeth Murphy, service support systems planner; (7) Carolyn Johnson, performance systems engineer; (8) Richa Sharma Pandey, billing recording systems engineer; and (9) Frank Liao, architecture testing systems engineer. See p. 20. Credit: Dave Hoffman for AT&T Bell Laboratories.



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Forum

Elegy upon a missing workstation

This evening we received in the mail to review,
The *IEEE Spectrum* of April '92.

With interest we turned to page 38,
To the workstation feature with offerings of late.

The charts were detailed and the comments were sound,
But our favorite workstations were not to be found.

There were Suns, IBMs, Tandys, Apples, and DECs,
But glaringly missing were computers from NeXT.

Sixteen DOS clones got lots of attention,
But unique Unix NeXTs? Not even a mention!

(On most other topics we are otherwise pleased
With the *IEEE Spectrum*. Signed, two EEs.)

Bryan and Lisa Talbot
Aurora, Colo.

We regret that NeXT did not respond to our survey. —Ed.

Bats, dogs, and pulling g's

I enjoyed the fascinating article "Through a bat's ear" [March, p. 46]. Something just as fascinating was not mentioned: bats seem to be smarter than dogs about catching their next meal. The bat flies a proportional navigational course to its target.

When a dog chases a rabbit, it runs a pursuit course toward the position of the rabbit it sees. As the dog approaches the rabbit, the angle between the dog's track and the rabbit's track decreases and the angular rate of change increases. The dog must constantly increase its lateral (centripetal) acceleration to intercept the rabbit, putting the dog in an increasingly high-g turn. If the rabbit maneuvers to escape in the terminal phase, the rabbit may succeed by exceeding the dog's ability to pull lateral g's on the chase surface.

The article's Figure 1 shows that after an initial transient, the line-of-sight angle from the bat's trajectory to the moth's is relatively constant. The bat flies a collision course with little change in line-of-sight angle and low lateral acceleration. Whatever lateral g's the bat can pull are conserved until the terminal phase. When the moth maneuvers, as in the figure, the bat is still likely to have the aerodynamic g's to catch its dinner.

The bat's sensor is remarkable, but so is its navigational system. As the bat senses the target with its mouth and ears, something causes it to fly a constant angle between its line of flight and its line of sight to its target. Could we have a sequel about the bat system—sensor plus navigation?

George F. Steeg
Reston, Va.

Remembering Fessenden

Now, when there are documentaries that lament the demise of dramatic radio, praise the work of Marconi, and laud the radio impresarios of the 1920s and '30s, everyone seems to have forgotten Reginald Aubrey Fessenden. The Canadian-born and -educated teacher of mathematics first broadcast the human voice and music long-distance on Christmas Eve, 1906.

Fessenden's lifelong ambition was to transmit the human voice by wireless. After holding posts with Edison, Purdue University, and the University of Pittsburgh, he obtained funding for wireless telegraphy from two Pittsburgh businessmen, Thomas H. Given and Hay Walker Jr. In return for sharing in his patents, they created the National Electric Signalling Co., dedicated to wireless telegraphy between the stations that Fessenden would build in New York City, Philadelphia, and Washington, D.C.

Wireless telegraphy was not Fessenden's goal, but association with it gave him the opportunity for further experimentation with wireless telephony. Given and Walker then desired to create two-way transatlantic telegraphy and directed Fessenden to develop the necessary equipment. The sites chosen for the station were Brant Rock, Mass., and Machrihanish, Scotland.

Fessenden commissioned the General Electric Co. to develop a high-frequency alternator. Although such a device was delivered, its performance did not please Fessenden—so he rebuilt it to operate at a higher speed, one that generated a higher frequency (ca. 100 kHz). The alternator was then connected to the Brant Rock station antenna.

Since the Scottish station had no alternator then, Machrihanish was used as a receiving station. When the signal was received, the response was sent via the transatlantic cable and then relayed by telephone to Brant Rock. One-way telegraphic signaling to Scotland began. Soon the telephone at Brant Rock rang and the relayed message was, "Getting you, Brant Rock, loud and clear."

Later, a suitable high-frequency alternator was installed in the Scottish station and, beginning in the spring of 1906, two-way transatlantic wireless telegraphic signaling became a daily event.

Meanwhile, Fessenden had built a second experimental station at Plymouth, Mass. During off-hours, he used this station to test improvements in modulation and detection. While these tests were going on, he received a letter from Scotland in mid-November 1906 indicating that they had overheard these test voice communications. The text of the letter matched, word for word, the entry in Fessenden's log of that day.

During this time the United Fruit Co. had bought Fessenden's apparatus for receiving wireless telegraphy for the banana boats plying the Caribbean and South Atlantic. Fessenden accordingly arranged for a demonstration to be presented at the end of a routine wireless telegraphic communication with the United Fruit ships.

At 1:00 a.m. on Dec. 24, 1906, Fessenden, his wife Helen, and technician Adam Stein faced the asbestos-covered microphone in series with the antenna at Brant Rock. First, the CQ-CQ-CQ general call to all stations was sent out in Morse code. Then Fessenden gave a short speech, after which an Edison phonograph playing Handel's "Largo" was broadcast. Fessenden then played "O Holy Night" on his violin and sang the last verse at the same time. (The others were supposed to sing along with him, but they could not. They may be recorded as the first persons to have "mike-fright.")

Fessenden finally wished his listeners a Merry Christmas and promised a repeat performance on New Year's Eve. (The performance was repeated and included vocals from his associates who had overcome their fear of the microphone.) Mail was soon received from the United Fruits' ships and a number of other ships in the North and South Atlantic. Fessenden had reached his goal!

L. A. Geddes
West Lafayette, Ind.

Readers are invited to comment in this department on material previously published in *IEEE Spectrum*; on the policies and operations of the IEEE; and on technical, economic, or social matters of interest to the electrical and electronics engineering profession. Short, concise letters are preferred. The Editor reserves the right to limit debate on controversial issues. Contacts: Forum, *IEEE Spectrum*, 345 E. 47th St., New York, N.Y. 10017, U.S.A.; fax, 212-705-7453.

Calendar

Meetings, Conferences and Conventions

JUNE

Symposium on Computer-Based Medical Systems (C, EMB); June 14–17; Washington Duke Inn and Golf Club, Durham, N.C.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

International Conference on Communications—ICC/Supercomm '92 (COM, Chicago Section); June 14–18; Chicago Hilton and Towers, Chicago; P. Douglas Lattner, Ameritech Services, 2000 W. Ameritech Center Dr., Hoffmans Estate, Ill. 60196-1025; 708-248-5302.

International Semiconductor Manufacturing Science Symposium (ED, CHMT); June 15–17; Moscone Convention Center, San Francisco; Corinne Cargnoni, SEMI, 805 E. Middlefield Rd., Mountain View, Calif. 94043; 415-940-6950.

Second International Conference on Systems Integration (C); June 15–18; Headquarters Plaza Hotel, Morristown, N.J.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

Seventh Annual Conference on Computer Assurance (AES, NCAC); June 15–18; National Institute of Standards and Technology (NIST), Gaithersburg, Md.; Rob Ayers, 2551 Riva Rd., Annapolis, Md. 21401; 410-266-4741.

Fourth International Conference on Software Engineering and Knowledge Engineering (C); June 17–19; Europa Palace Hotel, Capri, Italy; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

Solid-State Sensor and Actuator Workshop (ED); June 21–25; Marriott Hilton Head Resort, Hilton Head Island, S.C.; Steve Senturia, Massachusetts Institute of Technology, Room 39-567; Department of Electrical Engineering, Cambridge, Mass. 02139; 617-253-6869; fax, 617-253-9606.

International Workshop on Hardware Fault-Tolerance in Multiprocessors (C); June 22–23; University of Massachusetts, Amherst; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

IEEE members attend more than 5000 IEEE professional meetings, conferences, and conventions held throughout the world each year. For more information on any meeting in this guide, write or call the listed meeting contact. Information is also available from: Conference Services Department, IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855; 908-562-3878; submit conferences for listing to: Ramona Foster, *IEEE Spectrum*, 345 E. 47th St., New York, N.Y. 10017; 212-705-7305.

For additional information on hotels, conference centers, and travel services, see the Reader Service Card.

Calendar

(Continued from p. 8)

50th Annual Device Research Conference (ED); June 22–24; Massachusetts Institute of Technology, Cambridge; Sam Shichijo, Texas Instruments Inc., 12840 Hillcrest, Suite 200, Dallas, Texas 75230; 214-917-7402.

Seventh Annual IEEE Symposium on Logic in Computer Science (C); June 22–25; University of California, Santa Cruz, Calif.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

35th International Power Sources Symposium (IA); June 22–25; Hyatt Cherry Hill, Cherry Hill, N.J.; Conference Registrar, IEEE Technical Activities, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3894.

20th Power Modulator Symposium (ED); June 23–25; Myrtle Beach Hilton Hotel, Myrtle Beach, S.C.; Mark Goldfarb, Palisades Institute, 2011 Crystal Dr., Suite 307, Arlington, Va. 22202; 703-769-5588.

American Control Conference (CS); June 24–26; Westin Hotel, Chicago; Dale Seborg, Chemical and Nuclear Engineering Department, University of California, Santa Barbara, Calif. 93106; 805-961-3352.

Optical Amplifiers and Their Applications (LEO); June 24–26; Eldorado Hotel, Santa Fe, N.M.; Optical Society of America, 2010 Massachusetts Ave., N.W., Washington, D.C. 20036-1023; 202-223-0920; fax, 202-416-6100.

JULY

International Broadcasting Convention—IBC '92 (Benelux, UKRI Section); July 3–7; RAI Congress Center, Amsterdam, the Netherlands; IBC Secretariat, c/o IEEE, Savoy Place, London WC2R OBL, England; (44+071) 240 1871; fax, (44+071) 497 3633.

Fifth International Workshop on Computer-Aided Software Engineering (C); July 6–10; Queen Elizabeth Hotel, Montreal; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

22nd International Symposium on Fault Tolerant Computing (C); July 8–10; Lafayette Hotel, Boston; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

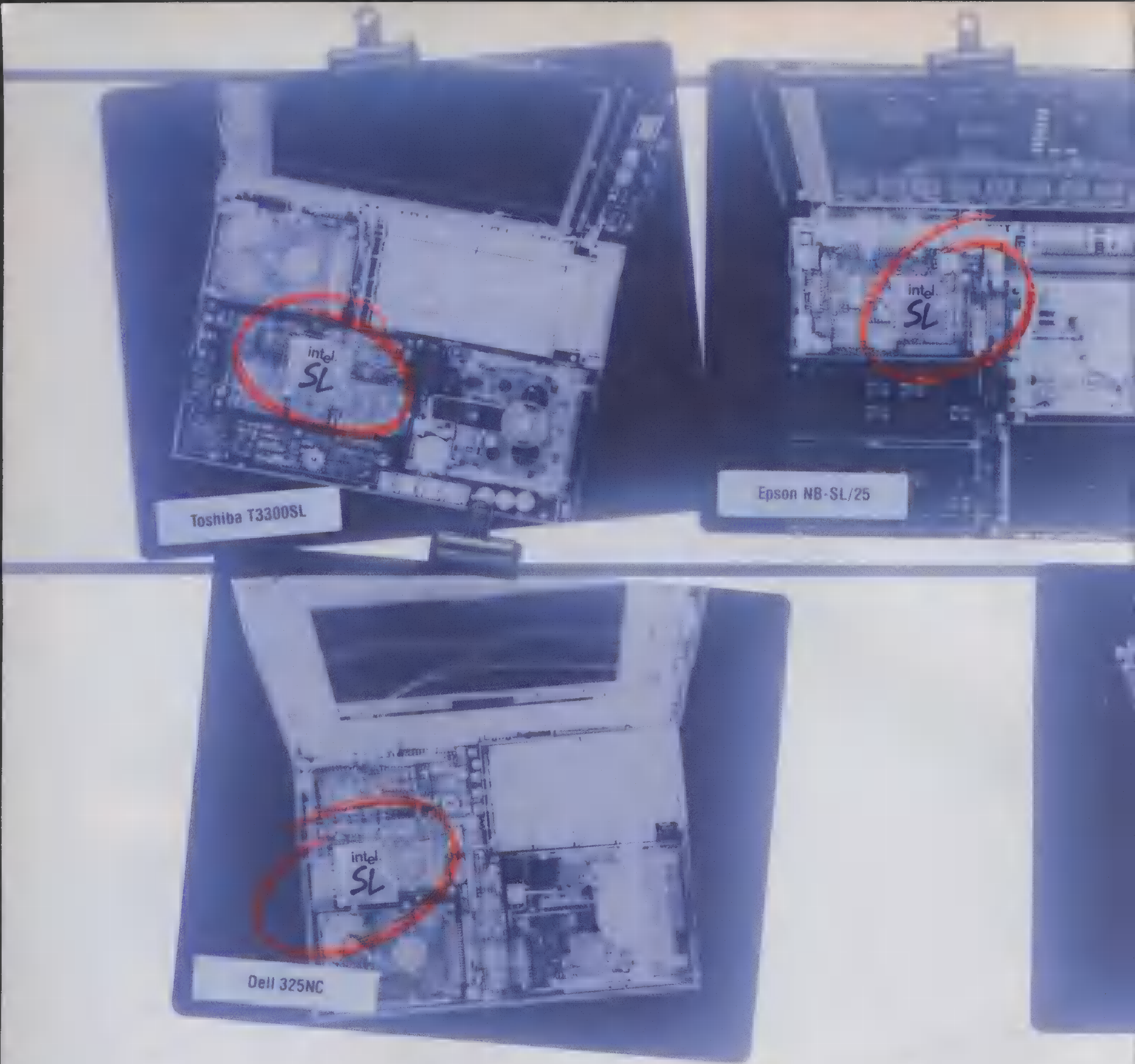
Power Engineering Society Summer Meeting (PE); July 12–16; Westin Hotel, Sheraton Hotel and Towers, Seattle, Wash.; R.M. Youngs, Seattle City Light Co., 1015 Third Ave., Seattle, Wash. 98104-1198; 206-684-3040.

International Microprocess Conference (ED); July 13–16; Kanagawa Science Park, Kawasaki, Japan; Tsuyoshi Yuri, 3-23-1 Hongo, Bunkyo-ku, Tokyo 113, Japan; (81+3) 3817 5831; fax, (81+3) 3817 5836.

Fifth International Vacuum Microelectronics Conference (ED); July 13–17; Hotel Chateau Wilhelminenberg, Vienna, Austria; Johannas Mitterauer, Technical University of Vienna, Institut für Allgemeine, Elektrotechnik und Elektronik, Gusshausstrasse 27–29, A-1040 Vienna, Austria; (43+1) 588 01 3682; fax, (42+222) 505 2666.

Nuclear and Space Radiation Effects Conference (NPS); July 13–17; Hyatt

(Continued on p. 8F)



Look what's at the heart

Take a closer look at some of the best notebook computers and it's easy to see why the prognosis is so good—they each have an Intel SL microprocessor.

The Intel SL gives each of these unique notebooks a leg up, because it was designed specifically for the stop-and-go world of mobile computing.

For example, the Intel SL has an instant on/off feature that eliminates long boot-up and shut-down sequences. If you're interrupted, the Intel SL holds your place and puts your entire system into suspended animation, using virtually no

Battery Life*

Average 386 SX 4.8 hours | **Intel386™ SL 8.2 hours**

Calendar

(Continued from p. 8B)

Regency Hotel, New Orleans, La.; James R. Schwank, Sandia National Laboratories, Division 1332, Box 5800, Albuquerque, N.M. 87185; 505-844-2150; fax, 505-846-5004.

Antennas and Propagation Society International Symposium, URSI National Radio Science Meeting, and Nuclear EMP Meeting (AP); July 18–25; Hyatt Regency Hotel, Chicago; Sharad R. Laxpati, Department of EECS (M/C 154), University of Illinois at Chicago, Box 4348, Chicago, Ill. 60680; 312-996-5493; fax, 312-413-0024.

Magnetic Recording Conference (MAG); July 21–23; Santa Clara University, Santa Clara, Calif.; R.L. White, Mathematics and Science Department, Stanford University, Stanford, Calif. 94305-2205; 415-723-4431; fax, 415-725-4034.

LEOS Summer Topical Meeting: Broadband Analog and Digital Optoelectronics (LEO); July 29–31; Red Lion Inn, Santa Barbara, Calif.; IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 00855-1331; 908-562-3893.

AUGUST

Fifth Biennial Conference on Electromagnetic Field Computation—CEFC (MAG); Aug. 3–5; Harvey Mudd College, Claremont, Calif.; S. R. H. Hoole, Department of Engineering, Harvey Mudd College, Claremont, Calif. 91711; 714-621-8019.

LEOS Summer Topical Meeting: Optical Multiple Access Networks (COM, LEO); Aug. 3–5; Red Lion Inn, Santa Barbara, Calif.; IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3893.

27th Intersociety Energy Conversion Engineering Conference—IECEC '92 (ED, AES); Aug. 3–7; Town and Country Hotel, San Diego, Calif.; Scott R. Klavon, Staff Engineer, Society of Automotive Engineers, 400 Commonwealth Dr., Warrendale, Pa. 15096-0001; 412-776-4841, ext. 391.

LEOS Summer Topical Meeting: Integrated Optoelectronics (ED, LEO); Aug. 5–7; Red Lion Inn, Santa Barbara, Calif.; Susan Evans, IEEE/LEOS Executive Office, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3896; fax, 908-562-1571.

Third IEEE Workshop on Computers in Power Electronics (PEL); Aug. 9–11; University of California, Berkeley; Seth Sanders, Department of Electrical Engineering and Computer Science, Cory Hall, University of California, Berkeley, Calif. 94720; 415-642-4425.

35th Midwest Symposium on Circuits and Systems (CAS et al.); Aug. 9–12; Capitol Hilton, Washington, D.C; Lu Klemppinger, Director of Conferences, Division of Continuing Education, 2003 G St., N.W., Washington, D.C. 20052; 202-994-0723; fax, 202-994-7048.

LEOS Summer Topical Meeting: Smart Pixels (LEO); Aug. 10–12; Red Lion Inn, Santa Barbara, Calif.; IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855-1331; 908-562-3893; fax, 908-562-1571.

12th IEEE Nonvolatile Semiconductor Memory Workshop (ED); Aug. 12–14; Hyatt Regency Hotel, Monterey, Calif.; Jim Paterson, Texas Instruments Inc., 13536 N. Central Expressway, MS-944, Dallas, Texas 75243-1108; 214-995-5391.

(Continued on p. 8K)

IEEE-USA Member Forum Coming to Anaheim
—Speak Out On Professional Issues

What are the problems in your area right now? Unemployment? Competitiveness of your industry in global markets? Pensions? Here's your chance to hear what IEEE United States Activities (IEEE-USA) is doing about them. More than that, here's your chance to sound off on what you think IEEE-USA should be doing about them.

IEEE-USA's leaders are coming to Anaheim on Saturday, June 27, at the Anaheim Hilton, 777 Convention Way. Saturday morning, beginning at 8:30 a.m. and ending at noon, IEEE members are invited to come and speak their minds on professional problems. IEEE-USA's leaders want and need feedback from as many members as possible on what can and should be done to serve local members.

On Saturday, October 24, IEEE-USA's leaders will visit St. Louis, Missouri, for a Member Forum. Details will be announced later. A report of an earlier Forum held on April 4 in Baltimore, Maryland, is available from the IEEE-USA Office in Washington, D.C.

If you plan to attend the Anaheim Forum, mail or fax the response form or telephone the IEEE-USA office.

Yes, I'll be there.

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(202) 785-0017 (phone)
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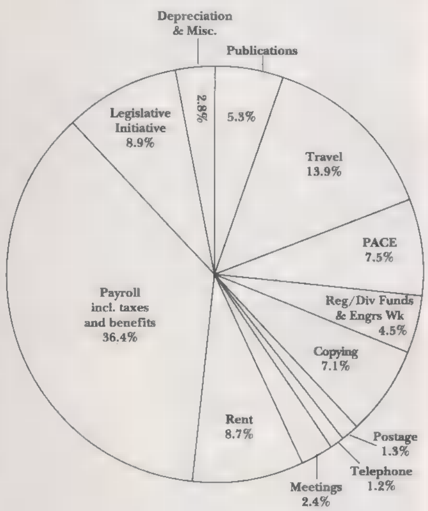
United States Activities Board Finances—
Where does the money come from, and where and how is it spent?

Income is derived primarily from the U.S. assessment of $22 per member, of which $19.95 goes to the USAB Operating Fund and $2.75 to the Restricted Fund. These amounts reflect the recently approved dues increase, which is being used to fund increased programs and to avoid negative reserves.

There are 225,000 IEEE members in the United States, but due to Life Members who do not pay dues or assessments, half-rate dues payers, and part-year members, only 166,000 members will really pay the U.S. assessment, for a budgeted income in 1992 of $3,195,500. Other income from investment of daily cash balances and product sales amounts to $184,500, for a total budget income of $3,380,000 for the General Fund. The income figures above reflect a reduced 1992 budget, due to near-zero growth in U.S. membership.

1992 Budget Expenses	Dollars	Percent
Publications, incl. *Professional Perspective, Impact, Hot Lines,* and Public Relations	$ 178,000	5.3
Vol. & Staff Travel	$ 467,000	13.9
Annual PACE Meeting	$ 250,000	7.5
Reg. 1-6 & Div. Funds and Engineers Week	$ 151,000	4.5
Copying & Duplicating	$ 237,000	7.1
Postage	$ 42,000	1.3
Telephone	$ 40,000	1.2
Meeting Accom.	$ 81,000	2.4
Washington Ofc. Rent	$ 290,000	8.7
Payroll (incl. taxes & benefits)	$1,222,000	36.4
Legislative Initiative	$ 300,000	8.9
Deprec. & Misc.	$ 94,000	2.8
Total	$3,352,000	100.0%



USAB operating procedures suggest that we have an operating reserve of 15% to 25% of our yearly expenses. In fact, in many years the reserve is below the 15% margin. Due to reduced income in 1992, the reserve will fall below 10%. Consequently, the Chairman and Controller have instituted a 5% holdback in the listed expenditures, to be reviewed later in the year.

The Restricted Fund is used to pay IEEE's commitment to ABET, the accrediting agency for engineering schools, and IEEE's support of the American Association of Engineering Societies (AAES). Starting in 1992, this fund will also pay the assessment for the National Coalition of Engineering Societies for Math and Science Education.

—James H. Beall
USAB Controller

Job Fairs Update

IEEE co-sponsored job fairs are planned (although not all contracts have been finalized) in these locations:

DATE	LOCATION
June 8-9	Boston Section (LG)
June 8-9	Bay Area Council (W)
June 15-16	Nat'l. Capital Area Council (LG)
June 15-16	Boston Section (BPI)
June 22-23	Dallas Section (LG)
June 22-23	Chicago Section (LG)
June 22-23	North Jersey Section (LG)
July 13-14	Bay Area Council (LG)
July 27-28	Nat'l. Capital Area Council (LG)
July 13-14	Bay Area Council (LG)
July 27-28	Nat'l. Capital Area Council (LG)
August 3-4	Detroit Section (LG)
August 3-4	Houston Section (LG)
August 17-18	Boston Section (LG)
August 17-18	Bay Area Council (W)
September 14-15	Chicago Section (LG)
September 14-15	Bay Area Council (LG)

Job fairs are open to all engineers. For more information on fairs marked (LG), please call (800) 562-2820; Virginia residents should call (800) 533-1827. For fairs marked (W), call (510) 866-8566, and for those marked (BPI), call (800) 328-4032. At each number, ask for the IEEE Career Fair Coordinator. ✦

From the Editor . . .

Welcome to *Professional Perspective* in *Spectrum*. IEEE's United States Activities Board has paid for this advertising space to bring news of professional activities to all U.S. members. We'll appear again in *The Institute*'s September-October issue, returning to *Spectrum* in December.

For now, space limitations prevent publication of full-length articles. Instead, we are presenting brief summaries, but you may request copies of reports or information on any professional programs from the IEEE-USA Office. Please don't hesitate to call (202) 785-0017; fax (202) 785-0835; or write to 1828 L Street, N.W., Suite 1202, Washington, D.C. 20036-5104.

Any comments? Questions? Suggestions? Complaints? Write to me in care of the IEEE-USA Office.

—Michael J. Whitelaw, P.E.
Editor in Chief

IEEE-USA Needs Your Help To Improve Pension Portability

Many engineers and scientists stand to lose a substantial part of their pension benefits, if they change or lose their jobs for any reason prior to retirement. Loss of retirement income due to changes in employment occurs for three major reasons:

- Workers fail to vest in an employer-sponsored pension plan;
- Workers receive their earned benefits in a lump sum at job termination and spend them, rather than reinvest them for retirement purposes; or
- Workers are covered by defined-benefit pension plans that calculate benefits on the basis of salary and years of service.

IEEE-USA Urges Changes in Pension Policy

To improve the portability of pension benefits when workers change jobs, IEEE-USA recommends that employers offer defined-contribution plans that permit immediate participation and vesting as the primary retirement savings vehicles for their employees. Benefits attributable to employer and employee contributions to such plans are generally fully transferable at the employee's option, upon termination of employment.

Workers who are covered by defined-benefit plans should also be able to roll over their earned benefits into Individual Retirement Accounts (IRAs) or other retirement savings arrangements, if they change jobs. In addition, the transfer or rollover value of such benefits should be calculated using a deflated long-term discount rate, rather than prevailing market interest rates, to help offset the adverse effects of inflation on purchasing power.

Why Is H.R. 2390 So Important?

H.R. 2390, the ***Pension Coverage and Portability Improvement Act,*** includes provisions that would help to expand pension coverage and eliminate the primary causes of the portability losses that currently reduce benefits and threaten the retirement income security of many mobile American workers. Congressman Sam Gibbons, (D-Florida), the second-ranking Democrat on the House Ways and Means Committee, introduced this legislation in 1991.

H.R. 2390 would require companies that do not currently sponsor pension plans to set up voluntary, salary-reduction savings arrangements (defined-contribution plans) for their employees. The legislation also would provide for full vesting of earned benefits after one year of service and encourage workers to save rather than spend pre-retirement, lump-sum distributions.

By permitting workers to transfer earned benefits to IRAs, if they change or lose their jobs before reaching retirement age, this bill would provide for portability from, defined-benefit plans. The bill also mandates the use of a three percent discount rate to determine the value of the benefits to be transferred or rolled over into an IRA from a former employer's plan.

What Should You Tell Your Representatives and Senators?

Communicate your support for the ***Pension Coverage and Portability Improvement Act*** to your Representatives and Senators in Washington, D.C. Urge your Representatives to co-sponsor H.R. 2390 and push for approval of its portability improvement provisions when the House takes up pension access and simplification legislation later this year.

Ask your Senators to work for introduction of the portability improvement provisions of H.R. 2390 in the Senate and to push for hearings on pension portability before the Senate Committee on Labor and Human Resources.

Be sure to tell your Members of Congress that prompt enactment of this important legislation is needed to improve the portability of pension benefits when workers change or lose their jobs, to increase individual savings for retirement, and to enlarge the pool of savings needed for productive investment in the nation's economy.

Include These Key Points in Letters of Support

Highlight these important points in your letters supporting H.R. 2390:

- Lifetime careers with a single employer have become the exception rather than the rule for most American workers. The average job tenure for engineers and other mobile professionals is less than seven years;
- Worker displacements due to corporate downsizings, mergers, acquisitions, and plant closings are a fact of life in today's troubled economy. Major reductions in defense spending can be expected to result in further layoffs and additional portability losses for many workers;
- Pension benefits that are left in former employers' plans are generally frozen and will be eroded by inflation between job termination and retirement;
- By mandating the use of a long-term real interest rate to determine the rollover value of defined benefits, H.R. 2390 will help offset the effects of inflation on the purchasing power of such benefits; and
- National productivity and competitiveness will be enhanced, if workers are able to move to jobs where their knowledge, skills, abilities, and experience can be applied as needed—instead of being "handcuffed" by pension plans that lack portability.

Letters from Constituents are Critical to H.R. 2390's Success

Simple, straightforward letters are still the most effective and most economical way to communicate your concerns to Members of Congress. Persuasive letters from a substantial number of IEEE members could mean the difference between success and failure in our efforts to improve pension portability for all American workers.

Take a few minutes to write three letters—one to your Representative and one to each of your two Senators. Even if you already have a portable pension, send letters anyway so that other engineers and scientists can be helped. A lot is at stake.

Where to Send Your Letters

Address your letters to Congress to the U.S. Senate, Washington, D.C. 20510, or to the U.S. House of Representatives, Washington, D.C. 20515. If you need assistance in identifying your Members of Congress, consult the reference pages of your telephone book or your local public library.

If you want more tips on communicating with Congress or need more information on pension issues and legislation, contact the IEEE-USA Office. ✦

Circle No. 16

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FIRMWARE ENGINEERS—Positions require a BSEE or BSCS and a minimum of 3 years of recent experience developing firmware in 68000 assembly and "C" preferred. Positions involve firmware and embedded software development.

RF HARDWARE ENGINEERS—Positions require a BSEE and 3 years experience in the detailed design of complex RF circuitry including UHF through SHF synthesizers, receivers, and modems. Positions involve development of RF/1F modules for open architecture SHF and Interferometer Systems.

COMMUNICATIONS SYSTEMS ENGINEERS—Positions require a BSEE (MSEE preferred) and 6 years experience in the calculations and trade analysis of complex communications systems, including link budgets, DSP, data/network layer protocols and modem implementations.

DIGITAL PROCESSOR ENGINEERS—Positions require a BSEE and a minimum of 3 years of digital microprocessor implementation design experience using 680x0 embedded processors. In addition, digital signal processing experience with TMS 320 processors and digital demodulator implementation experience is highly desirable.

SYSTEMS ENGINEERS—Positions require a BSEE or BSCS and a minimum of 3 years of experience in systems engineering including design, methodology and development processes on large hardware/software based signal processing systems. Experience with VAX/VMS, CADRE and Oracle desired. Positions involve requirements analysis and conceptual/functional design of large software subsystems.

REAL-TIME SOFTWARE ENGINEERS—Positions require a BSEE or BSCS and experience with 680x0 embedded processors/or TMS 320 digital signal processors. Experience with 680x0 assembly, "C," ADA in a UNIX development environment is desirable. Experience with a disciplined software development methodology (2167-A, NSAM-81-3).

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Calendar

(Continued from p. 8F)

Atomic and Nanoscale Modification of Materials: Fundamentals and Applications (ED); Aug. 16–21; Doubletree Hotel, Ventura, Calif.; Gordon Fisher, Cornell University, 423 Hollister Hall, Ithaca, N.Y. 14853; 607-255-7578.

International Symposium on Electromagnetic Compatibility (EMC); Aug. 18–20; Anaheim Marriott, Anaheim, Calif.; George M. Kunkel, Spira Manufacturing Corp., 12721 Saticoy St. South, North Hollywood, Calif. 91605; 818-764-8222.

International Conference on Solid-State Devices and Materials (EDS); Aug. 26–28; Daiichi Hotel, Tsukuba, Japan; Mitsuo Kawabe, Institute of Materials Science, University of Tsukuba, Ibaraki 305, Japan; (81+298) 53 5066; fax, (81+298) 55 7440.

International Symposium on Applications of Ferroelectrics (UFFC); Aug. 31–Sept. 2; Hyatt Regency Greenville, Greenville, S.C.; Gene Haertling, 206 Olin Hall, Clemson University, Clemson, S.C. 29634-0907; 803-656-0180.

SEPTEMBER

Second Singapore International Conference on Image Processing—ICIP '92 (Region 10); Sept. 7–11; Marina Mandarin, Singapore; ICIP '92 Secretariat, IEEE Singapore Section, 200 Jalan Sultan, 11–03 Textile Centre, Singapore 0719; (65) 291 9690; fax, (65) 292 8596.

Symposium on High Performance Distributed Computing (C); Sept. 9–10; Sheraton Hotel, Syracuse, N.Y.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

Application Specific Integrated Circuits Conference and Exhibit (C, Rochester Section); Sept. 21–25; Rochester Riverside Convention Center, Rochester, N.Y.; Lynne M. Engelbrecht, ASIC Seminar Coordinator, 170 Mount Read Blvd., Rochester, N.Y. 14611; 716-328-2310; fax, 716-436-9370.

13th International Semiconductor Laser Conference (LEO); Sept. 21–25; Takamatsu Kokusai Hotel, Takamatsu, Japan; 13th IEEE International Semiconductor Laser Conference, Business Center for Academic Societies Japan, 3-23-1, Hongo, Bunkyo-ku, Tokyo 113, Japan; (81+3) 3817 5831; fax, (81+3) 3817 5836.

Advanced Semiconductor Manufacturing Conference and Workshop (ED); Sept. 28–29; Cambridge Hyatt Regency Hotel, Cambridge, Mass.; Margaret Bachmeyer, Semiconductor Equipment and Material International Trade Group, 2000 L St., N.W., Suite 200, Washington, D.C. 20036; 202-457-9584.

13th International Electronics Manufacturing Technology Symposium (CHMT); Sept. 28–30; Hyatt Regency Inner Harbor, Baltimore, Md.; Bill Moody, 2529 Eaton Rd., Wilmington, Del. 19810; 302-478-4143; fax, 302-478-7057.

Challenges in Optoelectronic Packaging (LEO, CHMT); Sept. 30–Oct.1; Hyatt Regency, Baltimore, Md.; IEEE/Lasers and Electo-Optics Society, 445 Hoes Lane, Box 1331, Piscataway, N.J. 08855; 908-562-3893; fax, 908-562-1571.

International Professional Communication Conference—IPCC '92 (PC); Sept. 30–Oct. 2; La Fonda on the Plaza, Santa Fe, N.M.; Susan Dressel, Information Services, Los Alamos National Laboratory, Mail Stop M704, Los Alamos, N.M. 87545; 505-667-6101; fax, 505-667-1754.

Calendar

International Workshop on Hardware–Software Codesign (C, CAS); Sept. 30–Oct. 2; Holiday Inn, Estes Park, Colo.; IEEE Computer Society, Conference Department, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013; fax, 202-728-0884.

OCTOBER

GaAs Reliability Workshop (ED); Oct. 4; Fontainebleau Hilton Hotel, Miami Beach, Fla.; Anthony Immorlica, General Electric Co., Electronics Laboratory, Electronics Park, Syracuse, N.Y. 13221; 315-456-3514; fax, 315-456-0695.

International Symposium on Time-Frequency and Time-Scale Analysis (SP); Oct. 4–6; Victoria Conference Center, Victoria, B.C., Canada; Jan Kvamme, Engineering Continuing Education, University of Washington, 4725 30th Ave., N.E., Seattle, Washington 98105; 206-543-5539.

GaAs Integrated Circuits Symposium (ED); Oct. 4–7; Fontainebleau Hilton Hotel, Miami Beach, Fla.; Suzanne Kuntz, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, D.C. 20005; 202-347-5900.

International Telecommunications Energy Conference (PEL, COM); Oct. 4–8; J.W. Marriott Hotel, Washington, D.C.; Pete Paradissis, Reliance Telecommunications, 1122 F St., Lorain, Ohio 44052; 216-288-1122.

Bipolar/BiCMOS Circuits and Technology Meeting (ED); Oct. 5–6; Marriott City Center Hotel, Minneapolis, Minn; John Shier, VTC Inc., 2800 East Old Shakopee, Bloomington, Minn. 55425; 612-853-3292.

International SOI Conference (ED); Oct. 6–8; Marriott at Sawgrass Resort, Ponte Vedra, Fla.; Jerry Brandewie, Sematech (Rockwell International), 2706 Monpopolis Dr., Austin, Texas 78741; 512-356-3449; fax, 512-356-3521.

International Conference on Computer Design: VLSI in Computers and Processors—ICCD '92 (ED); Oct. 11–14; Royal Sonesta Hotel, Cambridge, Mass.; IEEE Computer Society, 1730 Massachusetts Ave., N.W., Washington, D.C. 20036-1903; 202-371-1013.

Military Communications Conference (COM); Oct. 11–14; Sheraton Harbour Island, San Diego, Calif.; John Peckham, General Dynamics, Box 85468, San Diego, Calif. 92138; 619-573-5452.

International Symposium on Systems Man and Cybernetics (SMC); Oct. 18–21; Knickerbocker Hotel, Chicago; Richard Saeks, Department of Electrical and Computer Engineering, Illinois Institute of Technology, Chicago, Ill. 60616; 312-567-3221.

Visualization '92 (C); Oct. 19–23; Boston Park Plaza Hotel, Boston; Georges Grinstein, University of Massachusetts at Lowell; 508-934-3627.

Workshop on Power Electronics in Transportation (PEL); Oct. 22–23; Hyatt Regency Hotel, Dearborn, Mich.; V. Anand Sankaran, Ford Motor Co., Room S-2037, Scientific Research Laboratory, 20 000 Rotunda Dr., Dearborn, Mich. 48121-2053; 313-390-8689.

26th Annual Asilomar Conference on Signals, Systems, and Computers (SP, C); Oct. 26–28; Asilomar Hotel, Pacific Grove, Calif.; James A. Ritcey, Department of Electrical Engineering, FT-10, University of Washington, Seattle, Wash. 98195; 206-543-4702; fax, 206-543-3842.

DEPARTMENT OF GENERAL SERVICES REQUEST FOR QUALIFICATIONS FIRE ALARM SYSTEM DESIGN/BUILD FIRMS

The New York City Department of General Services (DGS) is seeking to establish a List of Pre-Qualified engineering and consulting firms with experience in the design, development, construction and reconstruction of Fire Alarm Systems in connection with Capital Project PW-293. DGS may invite firms on this list of pre-qualified vendors to receive RFP's (Requests for Proposals) to propose on selected Captial Construction projects *without additional public notification.*

The Criteria to be used to Pre-Qualify the vendors shall include but are not necessarily limited to the following:

1. A minimum of five years experience in analysis, design and/or construction of Fire Alarm Systems.
2. Previously demonstrated experience in developing criteria to evaluate individual buildings need for a Fire Alarm System.
3. Experience in inspection, diagnosis, repair and activation of existing fire alarm alternatives.
4. Cost estimating experience and the ability to determine long term costs of various alternatives.
5. Demonstrates extensive knowledge of Local Law #5 and Local Law #16 in order to file with Regulatory Agencies to receive certification. Will monitor the project and will be available until all approvals are attained.
6. Firm's prior history and present plans in the area of minority and women's employment; the firm's utilization of the local, small, women-owned and minority-owned enterprises as subcontractors and the firm's plans to utilize these enterprises during the period of prequalification.
7. The consultants will be responsible for:
   - A. Performing on site surveys to identify existing conditions;
   - B. Prepare proposals for Department of General Services approval;
   - C. To prepare contract documents based on approval proposals;
   - D. Hire contractors;
   - E. Monitor construction;
   - F. Obtain Fire Department of New York and New York Building Department Certification and/or approvals.

Interested firms should submit standard form 254 together with other pertinent information to: James A. Trent, Division of Design and Construction Management, Municipal Building, Room 2141, 1 Centre Street, New York, NY 10007, Telephone (212) 669-7978 – Facsimile (212) 669-3606.

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David N. Dinkins
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Recent books

WordBasic Primer. *Borland, Russell,* Microsoft Press, La Vergne, Tenn., 1991, 331 pp., $22.95.

High-Tech Ventures: the guide for entrepreneurial success. *Bell, Gordon C.,* with *McNamara, John E.,* Addison-Wesley, Reading, Mass., 1991, 385 pp., $29.25.

Designer's Handbook of Instrumentation and Control Circuits. *Carr, Joseph J.,* Academic Press, San Diego, Calif., 1991, 617 pp., $99.50.

80386/80486 programming guide. *Nelson, Ross P.,* Microsoft Press, La Vergne, Tenn., 1991, 476 pp., $24.95.

Electrical Transients in Power Systems, 2nd edition. *Greenwood, Allan,* John Wiley & Sons, Somerset, N.J., 1991, 751 pp., $79.95.

Problem Solving for Engineers and Scientists. *Friedman, Raymond,* Van Nostrand Reinhold, New York, 1991, 156 pp., $19.95.

Cogeneration Planner's Handbook. *Orlando, Joseph A.,* Fairmont Press, Lilburn, Ga., 1991, 314 pp., $74.

Dynamic Analysis of Robot Manipulators: A Cartesian Tensor Approach. *Balafoutis, Constantinos A.,* and *Patel, Rajnikant V.,* Kluwer Academic, Dordrecht, the Netherlands, 1991, 292 pp., $69.95.

Pressure Sensors. *Tandeske, Duane,* Marcel Dekker, New York, 1991, 312 pp., $89.75.

Building Turbo Pascal Libraries. *Soybel, Jeremy G.,* Windcrest/McGraw-Hill, Blue Ridge Summit, N.J., 1991, 443 pp., $24.95.

Testing and Diagnosis of Analog Circuits and Systems. Ed. *Liu, Ruey-wen,* Van Nostrand Reinhold, New York, 1991, 284 pp., $54.95.

Electrical Spectrum and Network Analyzers. *Helfrich, Alber D.,* Academic Press, San Diego, Calif., 1991, 212 pp., $54.95.

Microsoft Excel 3 Companion. *Cobb, Douglas, et al.,* Microsoft Press, La Vergne, Tenn., 1991, 881 pp., $27.95.

Introduction to Ultrathin Organic Films. *Ulman, Abraham,* Academic Press, San Diego, Calif., 1991, 442 pp., $65.

Silicon-on-Insulator Technology: Materials to VLSI. *Colinge, Jean-Pierre,* Kluwer Academic, Dordrecht, the Netherlands, 1991, 228 pp., $59.95.

War in the Age of Intelligent Machines. *DeLan-*

(Continued on p. 60C)

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331 pp., $22.95.

High-Tech Ventures: th rial success. *Bell McNamara, John* Reading, Mass., 199

Designer's Handbook Control Circuits. *Car* Press, San Diego, $99.50.

80386/80486 progra *Ross P.*, Microsoft Pr 1991, 476 pp., $24.9

Electrical Transients in tion. *Greenwood, Alla* Somerset, N.J., 199

Problem Solving for E *Friedman, Raymonc* hold, New York, 19

Cogeneration Planner *Joseph A.*, Fairmont 1991, 314 pp., $74.

Dynamic Analysis of Cartesian Tensor Appr *stantinos A.*, and *Pat* er Academic, Dordre 1991, 292 pp., $69.9

Pressure Sensors. *Ta* Dekker, New York,

Building Turbo Pascal *my G.*, Windcrest/Mc Summit, N.J., 1991,

Testing and Diagnosis Systems. Ed. *Liu, R* Reinhold, New York,

Electrical Spectrum *Helfrich, Alber D.*, Diego, Calif., 1991,

Microsoft Excel 3 Com *et al.*, Microsoft Pre 1991, 881 pp., $27.9

Introduction to Ultrathi *Abraham*, Academi Calif., 1991, 442 pp.

Silicon-on-Insulator T VLSI. *Colinge, Jean-P.* ic, Dordrecht, the N pp., $59.95.

War in the Age of Intell

Books

Birth of a legend

Ross Bassett

IBM's 360 and Early 370 Systems. *Pugh, Emerson W., Johnson, Lyle R., and Palmer, John H. MIT Press, Cambridge, Mass., 1991, 832 pp., $39.95.*

The best works of history do not address the present by making overt comparisons with the past, but rather they examine timeless themes and force the reader to come to grips with his or her own application of those themes to the present. Although the computer industry is somewhat young to have timeless themes, over the last 30 years compatibility has been an issue upon which many computer companies have risen or fallen.

This book is built around that theme, and as such is sure to give the contemporary computer designer or executive plenty of food for thought (but, alas, no solutions).

In the early 1960s, IBM Corp. marketed five incompatible computers, including models designed for business or scientific applications, but not both. The experience led the company to try to develop a wide-ranging system of computers that would be both upwardly and downwardly compatible. The authors chronicle the opposition within IBM from those who did not want to abandon the earlier computer lines and from designers committed to the new systems who protested that the requirements of compatibility would hobble their machines.

While System/360 was a spectacular success, IBM was at other times tripped up by the compatibility issue. An effort to develop a universal programming language, a sort of software analog to the System/360, failed. PL/1, designed to be used for both scientific and business applications, fell behind schedule and was unable to displace either Fortran or Cobol, let alone both. Ultimately, IBM became a captive of the success of System/360 as the innovative Future System (FS) project was canceled, largely because of its incompatibility with System/360.

Anyone who doubts the relevance of the FS episode should consider the following sentence, replacing FS with PS/2: "No matter how good FS might be or how successfully its objectives were met, it would enter a market in which IBM no longer had control of its own product."

This book, which covers the period between 1960 and 1975, is part of an ongoing effort by IBM to document its technical history and relies heavily on internal documents and interviews with key figures. Most technical aspects are discussed, including architecture, semiconductor technology, peripherals, operating systems, and programming. However, the authors do not assume the reader is a specialist in any area and include basic explanations of most technical concepts covered.

System/360 encompassed so many developments crucial to the later evolution of smaller computers—including the floppy and Winchester disks—that anyone with a serious interest in computers will profit from reading the book. But this is not a work for the faint of heart or weak of arm. It is a big book, with a daunting procession of engineers, managers, and products.

One of its attractive aspects is its honest portrayal of engineers' work—much like Tracy Kidder's *The Soul of a New Machine*. Failure plays a prominent role in the book, with unsuccessful projects receiving the same attention as successes. Among the abortive projects discussed are alternatives to core memories, assorted

Books

magnetic peripheral storage products, and several advanced computer projects.

The authors show that in key areas the success of System/360 was not readily apparent. Researchers at the Massachusetts Institute of Technology and Bell Telephone Laboratories perceived the 360 as a failure because of its time-sharing inadequacies. IBM's own top management initially decided that System/360's hybrid circuitry was not advanced enough and demoted the manager deemed responsible. However, the authors used internal pricing data to conclude that, per circuit, IBM's costs were half those of companies that were then producing monolithic integrated circuits.

While the authors interviewed many of the key figures in the development of System/360, these interviews are heavily skewed toward those who completed their careers with IBM. For example, interviews with Gene Amdahl and Alan Shugart, who left IBM to work for competing companies, are conspicuously absent.

Also missing is any meaningful analysis of the motivations of those engineers who left IBM. Did they leave solely for the chance to make big money, or were there other reasons, such as a desire for more independence or control? While these may be delicate matters for an IBM-sponsored book, the authors treat other sensitive materials adeptly, and in view of the key role that defections have played in the computer and electronics industries, further examination was warranted.

While this is a comprehensive technical history of the development of System/360, the full story is much bigger than can be told in one volume. Beyond the scope of this work are discussions of IBM's marketing strategy and detailed comparisons of System/360 and its competitors. Also left out is the social impact of the 360. For example, how did the proliferation of mainframes change the ways in which companies do business? Although many questions remain, this is a fine work that fills in much of an important chapter in the history of computing.

Ross Bassett (S) is a Ph.D. candidate at Cornell University in Ithaca, N.Y., studying the history of the computer. He previously worked as an electrical engineer at IBM Corp.

COORDINATOR: Glenn Zorpette

Recent books

Barons of the Sky. *Biddle, Wayne,* Simon & Schuster, New York, 1991, 366 pp., $22.85.

Applied Illumination Engineering. *Fies-Lindsey, Jack L.,* Fairmont Press, Lilburn, Ga., 1991, 480 pp., $58.

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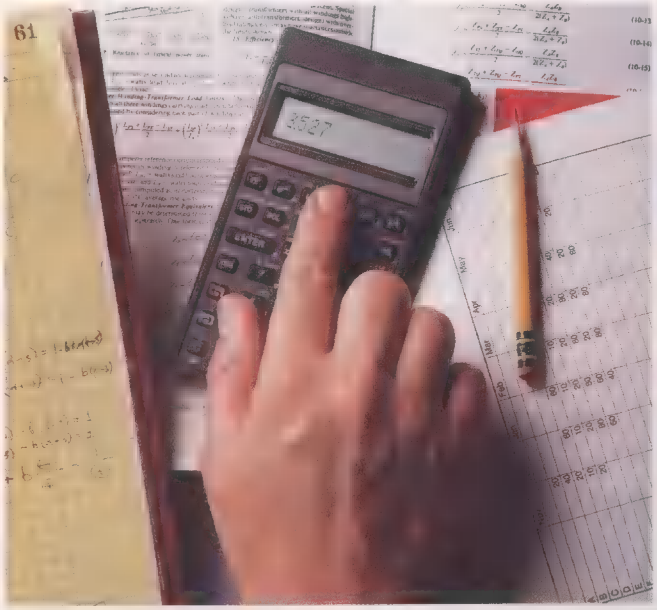

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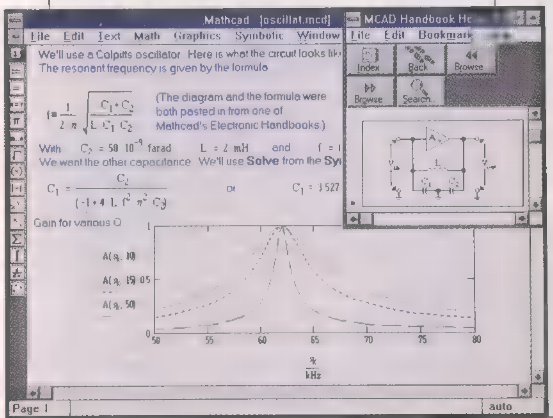

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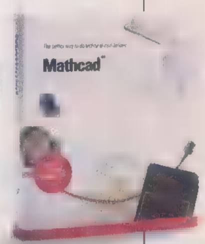

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Circle No. 8

Speakout

How to succeed in business

I find it amusing that many in electronics ridicule our brothers in the smokestack industries: "Those fools in Detroit have lost some twenty points of market share. Their products are terrible."

The U.S. electronics industry is doing as poorly as Detroit, so we have at least as much to gain by effective change as they do. We can prosper by regaining the share we have lost.

Domestically between 1979 and 1989, the United States lost about [redacted] 13 percent market share in aerospace and 14 percent in telephone equipment. Machine tools and semiconductors each lost 23 points of share, and the U.S. computer industry lost a whopping 28 points. Reports have it that Silicon Valley lost 5000 jobs in 1990, even more in 1991.

The United States uses traditional models for product development, business structure, and the role of government. These models, our fundamental beliefs, are today hopelessly outdated and noncompetitive. New methods promise order of magnitude improvements in market fit, in cycle time to a task's completion, and in quality.

Consider product development. Most U.S. companies still embrace functional organization. Whether in California or Michigan, we separate the various engineering disciplines and then we insulate them from marketing, finance, and production. This means that product development proceeds through distinct "chimneys" of activity, often sequentially. There are many opportunities for questions or objections to delay or cancel the product.

Leading firms, and the Japanese, use different paradigms. They prefer small, empowered, rapid-cycle, multidisciplined, market-centered, product development teams. Each team operates as a closed loop, containing all the authority, leadership, and expertise it needs to make decisions quickly.

U.S. companies are technology-centric. Our business model is technology transfer, or demand push—push the better mousetrap into the marketplace and it will win. Despite mountains of evidence to the contrary, we still think that technology innovation alone can prevail. This may have worked in the 1960s, but today's competition is smarter and a great deal quicker.

Today's market leaders practice "business innovation." This has three components, not just one. Winners exploit innovation in technology *and* market need *and* implementation.

Using the wrong paradigms and organizational forms is rather like playing tennis with a golf club. It puts you at a severe disadvantage when you come up against competent competition.

There is now debate over whether the United States should have a technology policy. The fact is that the country has had a policy since World War II, and billions are spent every year pursuing it.

The policy mostly takes the form of appropriating money for defense-related R&D and the development of military technologies. And now Congress hopes that opening the country's Federal laboratories to competition in the commercial sector will prove feasible and provide a significant competitive advantage with the development of new commercial products.

The assumption is that the primary aim of government investment in technology is creating new technology, and that new and better technology will bring prosperity. However, though this assumption worked in the past, it is wrong for today's intensely competitive global markets.

Imagine if someone who raised donkeys was suddenly transported to Africa and saw [redacted] zebra. His first impression might be that the beast was [redacted] donkey with stripes, whereas they are, of course, entirely different animals of similar appearance.

So it is with how businesses are organized. Appearances can be very deceiving. Today's market leaders may have structures, functions, and titles similar to what's found in traditional U.S. companies, but they are alien entities, who think and act differently.

Today's winners (be they American, Japanese, or European) are mostly applying technology to commercial products by means of business innovation. This is vastly different from technology transfer, but the differences appear minor when viewed superficially.

Japanese research laboratories are intimately coupled to market demand pull, while U.S. Federal labs are often criticized for their addiction to demand push. I was once the business development manager for the corporate research labs of a Fortune 500 firm, which had the same problem as the Federal labs. We were up to our ears in leading-edge technology, but moving concepts quickly from lab to market was almost impossible. It always has been, but in past eras of slow change, brand loyalty, and limited competition, it didn't matter much.

A few years ago Sony Corp.'s founder Akio Morita visited Bell Laboratories and was highly impressed with their technolo-

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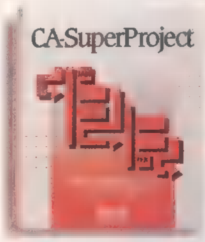

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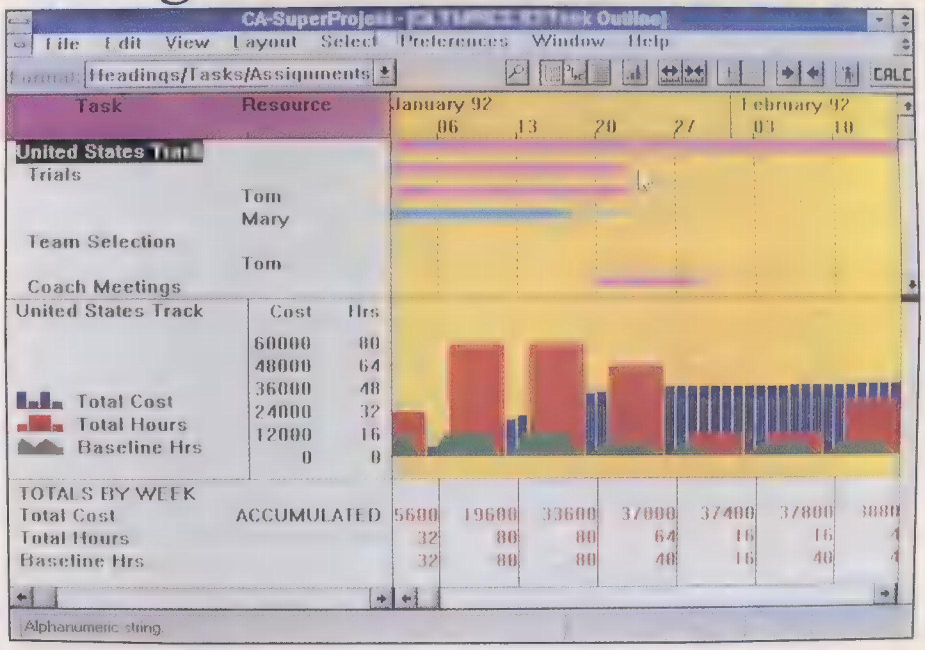

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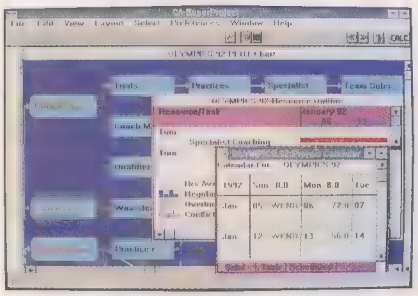

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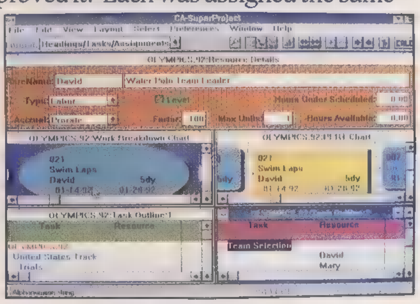

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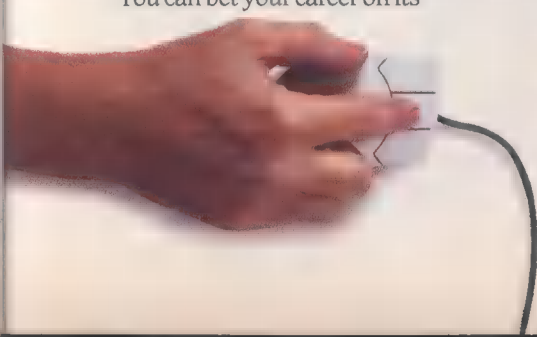


Circle No. 11

Speakout

gies. But, writing in the Japanese version of *The Japan that can say no*, he said he was astonished that nobody had the job of business development related to these technologies.

The United States' weaknesses are usually market fit, cycle time, effective implementation, quality, and the continuous improvement of a product once it has been introduced. Promising alternatives to technology push are alliances like the state of Colorado's buyer-supplier program for defense contractors. Rather than persuade companies to move into the state to aid the depressed economy, the idea is to build jobs at companies already there. Buyers and suppliers are encouraged to work together to develop products for the marketplace. Also in place are training programs that teach the companies how to operate in such alliances to produce high-quality, market-oriented products and do so quickly.

The Federal labs could help U.S. competitiveness if they adapted to business innovation. Unfortunately, they have far to go in converting their slow-moving bureaucracies to market-targeted entrepreneurships.

They can no longer concentrate on technology transfer. Instead, they must start with market needs and then find the technology to meet those needs. They must organize multidisciplinary teams of all those with a stake in bringing products to market. They must be willing to source technologies from everywhere, not just from their own labs. They must drive from outside in.

Today's exciting markets are characterized by nonstop innovation and endless streams of new products. Consider how the Japanese came to dominate consumer electronics. They applied business innovation to technologies invented here. Not only the Japanese can do this. Recall that Microsoft Corp. bought the original DOS and prospered by coupling it quickly and effectively to IBM's demand pull. Winners source technology from everywhere, and they move at warp speed.

And we will win or lose depending on how well-trained and empowered our professionals and our workers are in the context of multidisciplined teams. The Japanese have said that the United States will lose as long as the essence of Western business is to move the ideas of the bosses into the hands of the workers. They are correct.

John D. Trudel

John D. Trudel (M) is founder and director of The Trudel Group, a high-technology business development firm in Scappoose, Ore. He gives frequent lectures on business innovation and is the author of High Tech with Low Risk *(Eastern Oregon State College, LaGrande, 1990, 503-962-3755).*

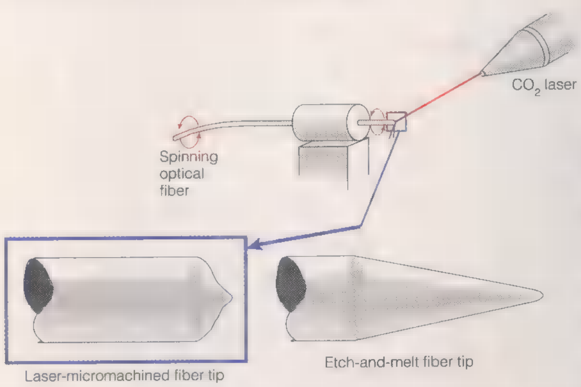
Hyperbola boosts coupling power of optical-fiber tip

Up to 90 percent of the light emitted from a semiconductor laser or amplifier is coupled into an optical fiber by a unique, hyperbolically shaped single-mode microlens. Other methods achieve at best 50 percent coupling efficiency. The new lens was invented at AT&T Bell Laboratories in Holmdel, N.J., by Herman M. Presby and his colleagues.

While microlenses are customarily etched and melted, the superior lens was created by a novel laser micromachining process that also improves the consistency and speed of microlens fabrication. Short, intense pulses of a narrowly focused carbon dioxide waveguide laser are applied to a fiber 125 micrometers in diameter to ablate small pieces of glass. The laser is set up in a fiber microlathe arrangement with a computer programmed to control the spinning fiber's movements.

In a conventional microlens, the end of an optical fiber is tapered to a point by hydrofluoric acid etching, then rounded by melting into a hemispherical tip that—for a very good lens—couples about half a laser's light output into the fiber.

The etch-and-melt fiber resembles a narrow, elongated cone, much like a sharpened pencil point [see figure]. In contrast, the micromachined fiber end is shaped like the top half of an onion dome, similar to those on certain Orthodox churches. More technically, the tip is given a unique aspheric (only one line of symmetry) hyperbolic shape, free of aberration, so that it captures most of a laser's light. Coupling efficiencies for the micromachined fiber are approximately 2.5 decibels better than those achieved with the etch-and-melt method.



Onion-dome-like tip on an optical fiber (left) has much more light-coupling efficiency than a conical tip.

U.S. Patent No. 333 230 was granted to Presby on April 5, 1989, for his method of and apparatus for fabricating microlenses on optical fiber, while U.S. Patent No. 444 578 was given on Nov. 30, 1989, to Presby and Christopher Edwards of AT&T Bell Labs for their method of coupling optical devices to optical fibers by microlenses.

Currents in polymers

Polyaniline, and possibly other conducting polymers as well, owe their electrical conductivity primarily to microcrystals, according to a research team headed by Alan MacDiarmid at the University of Pennsylvania in Philadelphia.

In one form, polyaniline is a microcrystal-containing polymer film. When it is stretched sixfold, additional pockets of crystals form, enabling the film after doping to conduct far more electricity than doped, nonstretched film can—two orders of magnitude more. The film is still some four orders of magnitude less conductive than copper, but further gains in conductivity may be achieved through techniques that increase the original amount of crystalline material.

Because conducting polymers combine the low cost and flexibility of plastic with electrical properties, their commercial use is being explored. They include shields against stray electromagnetic radiation, windows and displays that change color, and aircraft lightning-strike protection and radar avoidance.

Stretching any conducting polymer adds to its conductivity along the direction of stretch. Normally, polymers are haphazardly arranged, making it difficult for electrons to move from one chain-like molecule to another. When they are in parallel and close to one another as a result of stretching, however, electron motion between chains picks up, and so does conductivity.

But the Philadelphia team's research reveals that crystal-forming polymer films outdo non-crystal-forming films in conductivity, even if the latter are stretched 14 times as much. Stretching a crystal-containing film causes small, new, crystalline regions to form, increasing cross-links between polymer chains, explained MacDiarmid.

There are three polyaniline species, and at present conductivity after doping has been investigated mainly in the one that shows the greatest increase in conductivity—by approximately 10 orders of magnitude (from 10^{-7} to 10^{3} siemens per meter). MacDiarmid said the conductivity of the other two species will be investigated in greater detail in the future.

Digital storage for radiology

Hospital libraries of X-ray and other diagnostic film images are hard to manage efficiently. But matters should improve if the libraries switch to digital computer-based image and information management systems, also called picture archiving and communications systems (PACS).

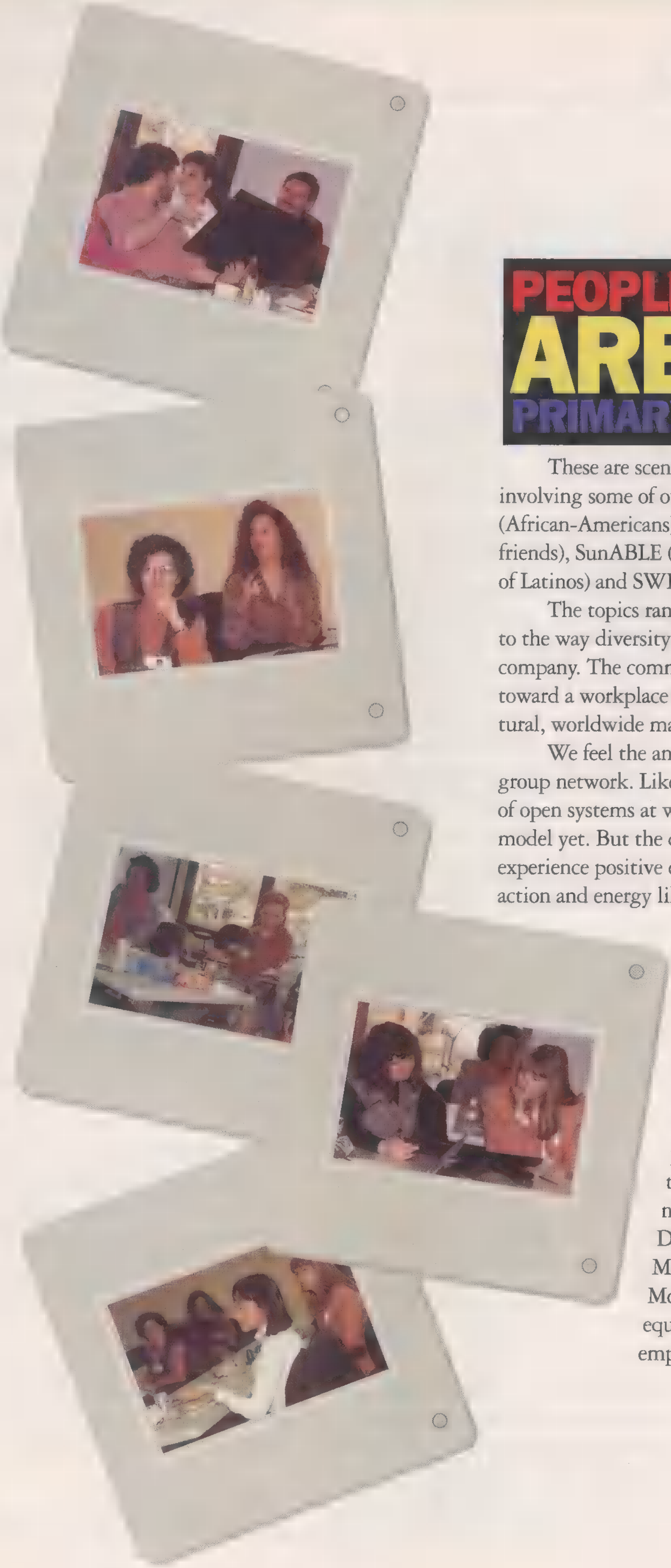
Collaborating on the first such open-architecture PACS system are Eastman Kodak Co. of Rochester, N.Y., and Vortech Data Inc. of Reston, Va. Called Ektascan Imagelink, the system allows hospitals to integrate it with existing equipment so as to custom-design a system to meet a facility's particular size, budget, and operational needs. The developers report that Ektascan Imagelink could save a hospital millions of dollars over all the stages of diagnostic image storage and distribution.

Currently images are captured or printed on film through X-rays, computed tomography, magnetic resonance imaging, nuclear medicine, or ultrasound. The film is then developed, interpreted, and stored in a hospital's radiology department, which the medical staff must visit to view results.

With Ektascan Imagelink, the diagnostic image is captured by the Vortech Medical Imaging Gateway—a software interface. It is then converted to the interface format prescribed by the American College of Radiology–National Electrical Manufacturers Association (ACR–NEMA) standard. Finally, it is distributed over a local- or wide-area network by coaxial cable, infrared, microwave, or satellite transmissions to an optical-disc library or a remote workstation.

The storage component of Ektascan Imagelink is Kodak's System 6800 disc library, which contains up to 100 platters, each 14 inches in diameter. Each platter can hold 10.2 gigabits of information—about 25 000 computed tomography or 70 000 ultrasound images. A library may store up to 1 terabyte of data in 2 meters of floor space, the world's smallest footprint per megabyte. This is possible with non-erasable, write once, read many times (WORM) disc technology, which has an archival life of more than 30 years and on-line access to images.

COORDINATOR: Dana Norvila
CONSULTANTS: Ralph H. Baer, Jacob Rabinow



Spectral lines

JUNE 1992 Volume 29 Number 6

Do students really get it?

There's ferment and activity in the reform of U.S. undergraduate electrical engineering curricula. After decades of discussion, this action seems long overdue.

What are the factors that have spurred this intensity of interest?

The timely drivers may be the decreasing enrollments in engineering schools, abetted by the siphoning away of potential engineering students to other disciplines.

But more fundamental reasons relate to the changing nature of the profession. Two elements are important. On the one hand, the needs of employers and thus the characteristics of an electrical engineering career are changing, and on the other, the preparation and motivation of students is changing.

Compounding the problem is inertia. When Carnegie Mellon University (CMU), Pittsburgh, undertook to redefine the undergraduate curriculum of its department of electrical and computer engineering in late 1989, it set no initial constraints, but was acutely aware that ''curricula have tremendous inertia, and often resist all but the most incremental and cosmetic of changes.'' The name of the reform committee anticipated this inertia. It was called the ''Wipe the Slate Clean Committee.'' There was a similar implication in the designation of a reform ''Phoenix Committee'' initiated at Worcester Polytechnic Institute (WPI) in Massachusetts.

> 'My students and I have forced ourselves through a distasteful process of pounding in material they find mysterious and useless and I find beautiful and important.'
>
> *CMU Professor James Hoburg*

Before it recommended any changes, WPI's Phoenix Committee tabulated some 300 responses from its EE alumni classes ranging back to 1960. Three categories of comment stood out. The first was the need for more practical, hands-on knowledge to accompany the traditional courses.

Many of today's students are less familiar with hardware than were earlier generations. They may be much more adept at using computers, but this computer literacy is often external—they don't know what's inside the box. One professor observed that the United States is no longer a nation of ''tinkerers.'' Students don't come to class knowing what a transistor or an electromagnetic relay looks like. They don't take things apart and put them back together anymore.

This was reinforced by the comments of WPI graduates that there's a need for more exposure to basic devices (relays, motors, and so on) and that courses should contain a project or practical applications component. They viewed the research or design project that is required of all WPI undergraduates as their most valuable experience.

The second observation of the WPI survey was closely linked to the first. It related to the systems aspect of engineering. The survey respondents called for additional course content involving project management, as well as more courses in non-EE disciplines (thermodynamics, fluid mechanics, and materials).

Finally, the survey results suggested more courses on the computer as an engineering tool and greater computer literacy in general (''The C language is a must for electrical engineers'').

Because of their general unfamiliarity with what electrical engineering really is, today's students seem less willing to believe that courses in math and physics will ultimately be useful later in core EE courses. This, coupled with an attention span that is notably shorter than that of previous generations, means that boredom and inattention may overtake even the conscientious students. Some may switch majors or even drop out, concluding that ''this is not what I thought electrical engineering would be.''

Furthermore, the compression of more material into the same number of classes has led to what the CMU committee called ''unit-creep.'' Thus, even the best of students find that a challenging course meant to require 12 hours of work per week inflates to needing 15 to 18 hours. Demands like this on students, the committee believed, leave less time for reflection, for considering alternative perspectives on similar problems, or for revisiting background material to ensure comprehension. It also noted that students react by viewing their courses as a set of unrelated hurdles to be overcome. They acquire ''a bag of seemingly unrelated problems and solution techniques'' without ever coming to understand the major ideas that bind those techniques together.

A professor who teaches linear circuits and electromagnetics at CMU has been widely quoted as saying, ''I've worked hard to help students achieve a rich and insightful understanding of fundamental material [and they tell me] I make even difficult and abstract concepts clear . . . Yet when I look at the reality of their understanding. . .the majority simply *don't get it*.''

Because of the ''wildly varying'' and often weak preparation in K-12 mathematics and science, any presupposition that students have the background, energy, and motivation to go acquire whatever math, science, and lab skills they lack, if pointed in the right direction, is incorrect, the Carnegie Mellon committee concluded.

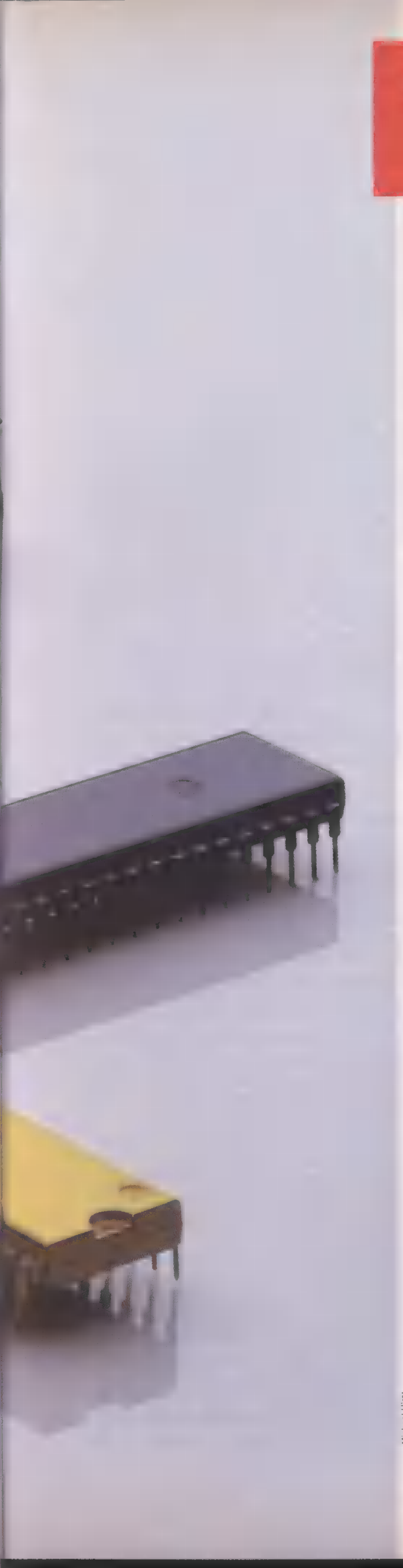
What happens in the first year is increasingly under scrutiny. Freshmen courses may offer no help in selecting a track (BSEE or BSCE at Carnegie Mellon) in the sophomore year. A sophomore may surprise a professor by asking something like this: ''Exactly what does a computer engineer do? And how does this course material help me to be a computer engineer? Is this different from computer science? Is the difference that we do hardware and they do software? Will I only be able to design big computers when I graduate? And why do I need all these circuits classes—aren't they for electrical engineers?''

The dilemma of whether electrical and computer engineering should be separate courses of study leading to distinctive degrees seems to be resolving itself in the direction of a wedding, not a divorce. Computers are not only the pervasive tools for engineers but also the product. Nevertheless, as new curricula are considered, the elements of both computer engineering and ''core'' electrical engineering courses must be woven together in ways that are neither obvious nor easy.

As schools grapple with these problems, individually and through consortia, they are reaching the conclusion that radical new solutions are necessary. In a future column we'll report on some of these innovative approaches.

Donald Christiansen

DIVERSITY IN THE HIGH-TECH WORKPLACE



The number of people who enter the U.S. workforce each year is steadily declining, a reflection of the declining birthrate. At the same time, the proportions of women, blacks, Hispanics, American Indians, and the foreign-born are growing. Between 1985 and 2000, native-born white men will constitute only 15 percent of the increase in the number of workers, the Hudson Institute predicted in its classic 1987 study, *Workforce 2000: Work and Workers for the 21st Century*. Women—white, nonwhite, and foreign-born—will constitute 64 percent of the increase, and native-born nonwhite and immigrant men will account for the balance.

The changing character of the workforce presents a major challenge to high-technology industry, which depends so strongly on people and ideas. With a smaller pool of talent to draw from, industry must cultivate new sources of engineers and scientists, in addition to the white men who have formed the backbone of the workforce.

The shift in the makeup of workers will also present important opportunities for women and minorities—provided that they are well-qualified for jobs that are becoming increasingly demanding. "Overall, the skill mix of the economy will be moving rapidly upscale," the Hudson Institute forecast, "with most new jobs demanding more education and higher levels of language, math, and reasoning skills."

Many U.S. corporations, large and small, are responding to these demographic trends by doing more than just passively accepting diversity; rather, they are positively embracing it. Their premise is that encouraging the best and the brightest, regardless of race, color, sex, religion, national origin, age, sexual orientation, or disability, gives them a competitive edge. The more diverse their talent, they believe, the more access they will have to creativity, ingenuity, and innovative ideas in a world where corporate success increasingly depends on such intellectual commodities.

The new corporate attitude differs strongly from earlier policies of equal opportunity and affirmative action. In the past, women and minorities were often hired into responsible jobs and simply left to languish in an unfamiliar environment. Companies sometimes played a quota game, happy that they could claim increasing numbers of women and minorities on their payroll, but giving only lip service to high-minded ideals. Diversity policies, in contrast, actively nurture nontraditional employees; companies now want them to succeed and to stay.

To speak of encouraging diversity in a period of widespread corporate downsizing may seem incongruous. Yet the facts remain that the workforce is being replenished at a decreasing rate and that high-technology companies need a continuing supply of talent as economic equilibrium returns.

In this special report, *IEEE Spectrum* asked experts from industry to examine aspects of the new workforce and the diversity it embodies. A pioneer in the field offers advice based on first-hand experience in implementing a diversity program. A diversity manager describes how affinity groups can help a diverse workforce work better together, a training expert shows how engineers can adapt to new cultures, and a human-resources professional presents a plan for helping diverse people prepare for greater responsibility.

We also asked management researchers to share their findings about job performance in diverse, highly technical work environments. They report revealing differences between the work experiences of U.S.-born white men and others.

And from four nontraditional engineers—a black, a Hispanic, a native American, and an Asian woman—we solicited firsthand accounts of their careers: why they chose engineering, their experiences at school and on the job, and the special qualities they feel they bring to the profession.

While the United States may be only beginning to encourage diversity, its successful application is not new. As one example, we examine diversity in microcosm in the city-state of Singapore.

—George F. Watson, Senior Editor

Diversity and performance in R&D

Women, with or without Ph.D.s, tend to rate themselves lower than men on innovativeness

New hires in U.S. R&D laboratories since the mid-1970s have changed from being almost exclusively U.S.-born men to being predominantly, in some companies, U.S.-born women or foreign-born scientists and engineers. At the same time, the proportion of native-born minorities has increased to a small extent.

Nancy DiTomaso and George F. Farris
Rutgers University

Michael Hirst

These new entrants find themselves in work environments where most of the managers are U.S.-born white men. And they are finding that their work styles, communication patterns, and personal needs do not always match those of the people who evaluate their performance.

To understand these and other issues, we are surveying scientists and engineers in R&D jobs in major industrial companies ["Surveying diversity," p. 22]. Our purpose is to determine whether a gap does

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exist between native-born white men and others and, if so, to gauge its extent and implications. And indeed, we are finding differences, both predictable and unpredictable, between the work experiences of native-born white men and the rest.

These differences make it important to understand now the issues confronting R&D managers. Most of what is known about managing R&D comes from studies of U.S.-born white men, yet our research shows the pathway to success may not be the same for others.

LEADING THE WAY. For companies that depend on innovation for their survival, these issues are fundamental. Whether good ideas get developed or squelched, whether people can build on each other's contributions (absolutely essential in today's R&D), and whether companies can keep good people depends on learning to manage diversity.

And for R&D to work well with other parts of the company, the differences within it and between it and the rest of the company must be bridged. Perhaps R&D is where these problems and opportunities can first be productively addressed. Perhaps R&D will lead the way for the rest of the corporate world.

Our study is continuing, but we can report on our findings on performance, teamwork, and leadership. Because the number of U.S.-born blacks and Hispanics in our sample is small, we can as yet form some conclusions only about women (mostly U.S.-born) and the foreign-born (mostly male).

THE BOTTOM LINE. Performance—how much of a contribution an individual is making—is the bottom line in R&D, as it is elsewhere in a company. We used four measures of performance, both self-assessment and managers' ratings: innovativeness (increasing knowledge through lines of R&D that are useful and new); usefulness (helping the organization carry out its responsibilities); promotability (readiness for advancement into management should an opening occur); and cooperativeness (effectiveness in working with others). We asked respondents and their managers to indicate, on a 100-point scale, what proportion of people the respondent "stands above." (The survey also includes self-reports on patents and publications. These correlate modestly with performance measures for U.S.-born white males, but not for foreign-born of either sex and only slightly for U.S.-born women.)

The foreign-born rate themselves higher than the U.S.-born on innovativeness, usefulness, and cooperativeness, but no differently on promotability [Fig. 1]. Their managers rate the foreign-born as no better than the U.S.-born on the first three dimensions and as lower on promotability. Interestingly, it makes no difference how long a foreign-born respondent has resided in the United States; manager ratings and self-ratings followed the same trend.

Of course, not all foreign-born are the same. We have to wait until our sample sizes are larger before we can comment on their differences. But we can say that males from Europe, Canada, and Australia (whom we call "Europeans") seem to rate themselves much as U.S.-born white males do.

Those from Asia, Southeast Asia, Africa, and Latin America (whom we call "non-Europeans") tend to rate themselves higher than U.S.-born white males and European males. Despite the differences among the non-Europeans, they tend to be more alike in their responses than they are like the Europeans. We do not have a large enough sample of foreign-born females to draw firm conclusions about them.

DOCTORATE HELPS WOMEN. Unlike the foreign-born males, women respondents rate themselves lower on innovativeness, usefulness, and promotability, but higher on cooperativeness [Fig. 2]. Managers also rate women as lower on innovativeness but as no different from men on usefulness, promotability, and, it turns out, cooperativeness.

When these differences are broken down further, the managers' lower rating for women in innovativeness applies only to those without a Ph.D.; women Ph.D.s are rated like men on all dimensions. Interestingly, women Ph.D.s are just as likely as non-Ph.D.s to rate themselves lower than men.

That even non-Ph.D. women are rated lower on innovativeness by their managers must be interpreted with caution because our study also shows that women have less opportunity to be innovative. For example, they are given less responsibility than men for initiating new activities and less freedom to work in their own way.

Surprisingly, on the measures of innovativeness and usefulness, the self-ratings of U.S.-born white men coincide almost identically with the ratings of their managers,

Surveying diversity

This article is based on surveys of about 2000 scientists and engineers in the R&D units of 18 major U.S. companies. Data collection is continuing. The Center for Innovation Management Studies at Lehigh University, Bethlehem, Pa., has funded the study; additional support comes from the Industrial Research Institute, New York City, and the Technology Management Research Center of Rutgers University, Newark, N.J. All companies have been promised confidentiality for themselves and their respondents.

The 18 companies currently participating include firms that hire large numbers of electrical engineers, representing about 180 respondents. Another three or four such firms are likely to join the survey. Other industries included are chemicals, industrial gases, petroleum, basic metals, pharmaceuticals, and consumer products.

All companies are multibillion-dollar enterprises. Although most are on the East Coast, companies from the Midwest, South, and West are included, and, of those headquartered on the East Coast, many have R&D facilities elsewhere.

The questionnaire for the surveys was developed by several researchers and the authors from focus groups and interviews in five large R&D facilities. The purpose of the surveys is to understand the management of a diverse scientific and engineering workforce. The questionnaire addresses work characteristics, career, relations with others including supervisors, work and family life, and self-assessment.

Some surveys were administered in group meetings at company sites; others were sent by mail. The overall return rate has been 60 percent. The number of respondents per company ranges from 25 to 650. The breakdown of respondents is:

1268 U.S.-born males (1213 white)
276 U.S.-born females (254 white)
303 foreign-born males (128 white)
53 foreign-born females (26 white)
64 blacks (40 U.S.-born)
185 Asians (15 U.S.-born)
46 Hispanics (15 U.S.-born)

The respondents are about equally divided among four seniority categories: under 2 years, 3–9 years, 10–20 years, and 21+ years. The U.S.-born white males, however, are, on the average, older than any of the other groups. As for education, about one-third of the respondents have Ph.D.s, one-fourth have master's degrees, and almost all the rest have bachelor's degrees.

In addition to the survey itself, the study includes data on performance from managers, as well as the respondents' perceptions of their own performance on four dimensions: innovativeness, usefulness, promotability into management, and cooperativeness.

POSITIVE AND NEGATIVE. Of the companies employing primarily electrical engineers, the responses were remarkably similar and were different from other responses in a number of ways, even though one has a higher-pressure environment and offers less job stability, and its respondents are more likely to say they will leave over the next 10 years.

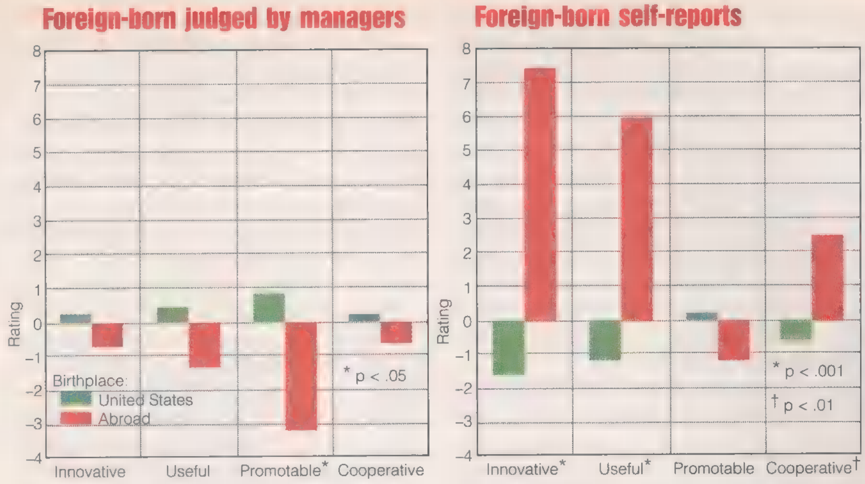
Positively, the respondents from these companies indicated:

- More favorability toward cultural diversity than those in other industries.
- Less concern about non-English accents.
- More opportunity to publish and build a reputation outside the company and more contacts with people inside the company.
- More leadership assignments.
- More client focus in projects.
- More Asian co-workers.

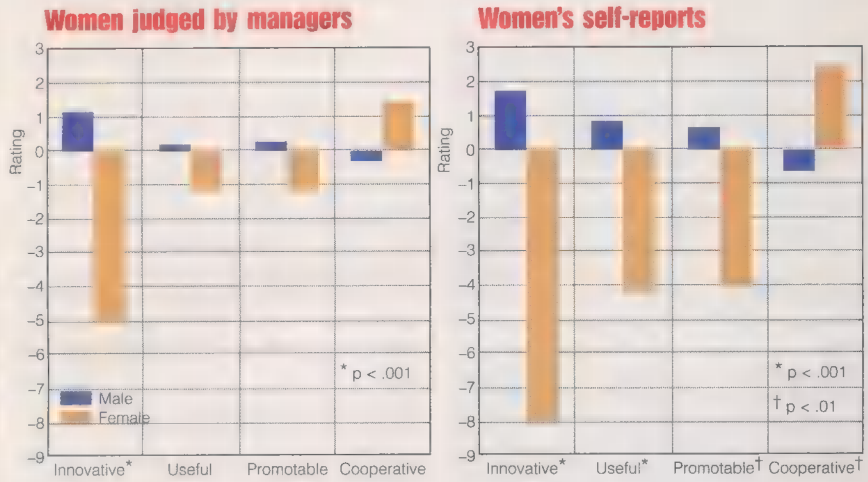
Negatively, they indicated:

- Less satisfaction with their jobs, their companies, and their supervisors.
- More negative attitudes toward their appraisal systems and their dual ladders.
- Less contact with colleagues and supervisors.
- Less career help from senior professionals.
- Fewer favorable opinions about supervisors.
- Less opportunity for advancement, less freedom to do work one's own way, less commitment from management to their work, less opportunity to initiate new activities, and less commercial success.

—N. DiT. and G. F.



*[1] Foreign-born scientists and engineers tend to rate themselves more highly on innovativeness, usefulness, and cooperativeness than their managers do. Performance values here and in Fig. 2 are deviations from the mean of all responses, adjusted for seniority, level of education, and gender. The term p is the probability that a result is due to chance; p = .01 means that there is no more than 1 chance in 100 that a difference as large as the one shown is a chance finding. * and † mark all statistically significant results.*



[2] Women scientists and engineers give themselves low ratings on innovativeness, usefulness, and promotability, and their managers tend to agree with them on innovativeness. If only Ph.D.s are considered, managers rate women like men (not shown here), although women with Ph.D.s still rate themselves low.

perhaps because they understand the culture around them and can easily interpret any feedback on how they are faring on the job. Of course, such insight may be aided by the fact that their managers are, for the most part, drawn from the same group as themselves.

In contrast, the non-European males not only rate themselves higher than do the U.S.-born, but also rate themselves much higher than do their managers.

Should we assume from the high self-ratings of non-European males and the low self-ratings of women (lower even than their managers) that neither non-European men nor women are attuned to the signals they are getting from those around them, or perhaps are not getting any signals at all?

PLAYING INTO STEREOTYPES. Besides uneven understanding of feedback, there may be other explanations for the discrepancies in assessment of performance. Both women and non-European men may be playing into the stereotypes about themselves, because the stereotypes may be reinforced by the ways in which they approach their work.

The fact that women are underrepresented in technical fields, for example, may contribute to stereotypical attitudes. It is undoubtedly difficult for those women who persist in getting technical training and who enter technical fields to have confidence that they are as good as the men around them. Otherwise, there would be more women, they may reason.

Further, research on performance appraisal indicates that, in jobs where the outcome measures are ambiguous, women do tend to rate themselves lower than men, while in positions where performance is easily measured, women rate themselves the same as men.

For the foreign-born—especially Asians and Southeast Asians—the opposite is true. Partly because U.S. immigration laws restrict legal entry and extended stays to those with "critical" work skills that are not otherwise available in the U.S. population, there is a bias in favor of foreign applicants in science and engineering fields. Thus, they tend to be overrepresented in such occupations, and perhaps need to believe themselves to be better than the U.S.-born.

Moreover, the foreign-born in our study place greater emphasis on their work; they are more involved, less concerned about spending time with their families, and attach more importance to success on the job. Therefore, they may have a higher investment in believing they are making a contribution.

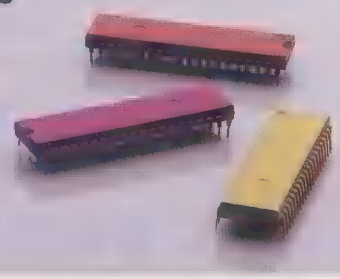
ARE MANAGERS BIASED? While recognizing these factors, we cannot dismiss the possibility of bias in the managers' ratings. If so, they are biased in favor of women and against the non-Europeans. Given that most women in our sample are themselves U.S.-born and white, it may be that managers understand their contributions better, but are less able to communicate with and evaluate the non-Europeans with whom they work.

On the other hand, if the managers' ratings are *not* biased, it is heartening to see that they differentiate less by demography than some might expect. Possibly, too, managers' ratings do not reflect their true feelings, but, even so, they could not easily manipulate the rankings. They were asked to rate individuals, while our measures are aggregated by subgroups of hundreds of people.

Clearly, managers need to examine their ratings for traces of bias attributable to cultural differences. Biased or not, managers must focus more attention on the kind of feedback they give, and probably on how they give it. They need to pay more attention to how the "rules of the game" are communicated and whether everyone in the game understands how to play.

PREVENTING FRUSTRATION. If a large and growing proportion of the labor force in R&D believe they are not getting rewarded for the contributions they believe they are making, they are likely to become frustrated. Frus-

As newcomers are promoted, a white male may wonder how he is being viewed



tration, in turn, often leads to poorer performance, a less productive work environment, and higher turnover.

Our study shows that the foreign-born, both Europeans and non-Europeans, are less likely to be satisfied than the U.S.-born with life in the United States, and they are more likely to say they would consider working abroad, either for their current or a different company. Non-Europeans are also more likely to want to start their own businesses than are the U.S.-born.

For women, their underestimation of their contributions is equally problematic. If women are more tentative about their contributions and less confident about what they have to offer, then they surely are not as likely to offer their opinions, to challenge those they think are on the wrong track, or to make suggestions about new directions.

Such speculation about the effects for both women and foreign-born scientists and engineers is consistent with what we have found for teamwork. There is no such thing these days as the isolated inventor. Problems are too complex and solutions too interdisciplinary for people to work alone.

In our measures of how well people work together, we are finding that women and foreign-born males differ in many respects from their U.S.-born male colleagues. (Again, non-European men are similar to each other, while European men are more similar to U.S.-born white men. U.S.-born women and foreign-born women are not as similar on the teamwork measures as they are on performance measures.)

A key indicator of teamwork is networking; generally, the larger one's network within R&D, the better one performs. We measured the size of a network as the number of people a subject talked to about work in a given time period. We find that the foreign-born talk to fewer people within their own laboratories than do the U.S.-born, though their networks are just as extensive outside the lab, both inside and outside the company.

Women resemble men in their lab and intracompany networks, but they talk to fewer people outside the company. While it is not clear which kind of network is most important for long-term career prospects, managers tend to rate those with large lab networks most highly.

We also evaluated teamwork by asking respondents about the level of cooperation they receive, both within R&D and across functions. The foreign-born respond like U.S.-born males on these measures, although they are less likely to work with other functions. Women report getting more cooperation than men from other functions such as marketing and manufacturing; in fact, they say this cooperation is greater than that from their own colleagues in R&D.

We probed further into cooperation by asking people about the characteristics of their own work group. Like the U.S.-born men, foreign-born men responded favorably about group cooperation and, on some questions, even more favorably. For example, they see greater similarity of work styles than U.S.-born men do.

Women, however, are less favorable. They report less confidence and trust within their group, less mutual support, less enthusiasm, less similarity in work styles, less comfort with the decision-making process, and less equality. They are less likely than men to agree with the direction of the group, to say that they themselves can influence the group, and to feel a part of the group.

The message therefore is mixed. The foreign-born generally get cooperation and feel quite comfortable in their groups, but they talk to fewer people in their laboratory about their work. Women talk to people in the lab, but seem to feel less fully accepted in their group. If interactions with others are limited, neither women nor the foreign-born are as likely to contribute fully—or to have their contributions fully recognized.

EVALUATING LEADERS. In all of this, the managers are the unknown quantity. We did not ask managers for self-evaluations or ask their superiors for appraisals. It would surely be interesting to correlate this kind of information with the results of our survey, and perhaps that will be possible in the future. But we did ask their subordinates to address the question of leadership.

In our focus groups before the survey, we heard again and again how important leadership is to subordinates; success in R&D *depended* on the manager—that is, the first-line supervisor—people told us. A good manager can help a scientist or engineer get ahead by giving highly visible assignments, smoothing interactions with others so that the job is easier to do, and offering coaching.

Women are more likely than men to get coaching and to have access to mentors and social networks, we found, contrary to the findings of most mentoring studies. The foreign-born are less likely to report having such access. Generally, however, the foreign-born respond favorably about their leaders, sometimes more favorably than U.S.-born men.

Women rate their supervisors lower than men on such issues as getting people to work together, letting people know where they stand, being sensitive to differences among people, and minimizing hassles with the staff. But women's opinions are just as favorable as men's on the ability of their supervisors to communicate goals, define problems, get resources, and motivate commitment, among other things.

BRIDGING GAPS. An encouraging aspect of our findings is that there is not more overt evidence of discrimination or exclusion for "new" groups in R&D on the part of either supervisors or colleagues. Differences seem to have more to do with culture than with competence and contribution. In other words, there may be avenues toward bridging gaps and managing diversity. But change will not occur without concerted steps toward a better mutual understanding and esteem for the differences that will persist.

We need to understand more the differences among the foreign-born and among women as groups, the sources of misperception and misunderstanding of contributions, the work dynamics that make some feel a part of the group and others excluded, and where managers can make a difference.

In most cases, U.S.-born white men have an edge over other groups in terms of integration into the work group, interaction with managers, and benefiting from the rewards of their jobs. Such distinctions cannot continue, however, as women and the foreign-born become more numerous in R&D. And as these newcomers get promoted into management, there may be questions as well about how they view incoming U.S.-born white males.

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Commitment from the top makes it work

David Barclay
Vice President, Diversity
Hughes Aircraft Co.

Like any major aerospace company, Hughes Aircraft Co. has had affirmative action programs for about 20 years. But our emphasis on workforce diversity began in 1987, when the Hudson Institute released *Workforce 2000*, with its predictions of a huge in-

flux of women and minorities into the workforce of the next century.

Hughes's management took that forecast very seriously. At the same time, the company was worried that the United States was not producing sufficient numbers of engineers and scientists. These concerns motivated Malcolm Currie, our former chairman and chief executive officer, to commit himself and the company to achieving diversity in our workforce.

To achieve our goal, we developed a variety of strategies. One was to establish employee networking organizations so that people with common interests could communicate with each other and with management, and management could communicate with them. Through such communication, of course, we wanted to create an environment that would encourage and value diversity. Currently, our employee network organizations are composed of women, Asians, blacks, Hispanics, and employees with disabilities.

We also set up a program of planned mentoring where experienced, respected managers were matched with promising new employees and asked to counsel and guide them. Mentoring has always existed on a spontaneous, informal basis at Hughes, but we wanted to institutionalize it, to give it explicit support and encouragement with the goal of developing women and minorities for positions of greater responsibility.

A third strategy was to expand our efforts to ensure a steady flow of qualified prospective employees through the educational "pipeline." Within a few years, the average high-school class in Los Angeles will be 50 percent Hispanic, 13 percent black, and 7 percent Asian—and the dropout rate is already 50 percent. To encourage high schoolers, and those from underrepresented groups in particular, to stay in school and study science and engineering, we began working on several projects.

One was the sponsorship of the Youth Motivation Task Force, a group of several hundred employees who visit junior and senior high schools to encourage students to consider a technical education. We also set up the Hughes Galaxy Institute for Education, which designs innovative and exciting curricula for kindergarten through fifth-grade students by using communication satellites, television, and interactive technology.

Accept and value diversity


Jon Brenneis

The National Society of Black Engineers—or NSBE—has had a major influence on my life. It is the organization that first introduced me to engineering when I was in high school in Chicago. And today I'm still active in it; I currently serve as NSBE's national chairperson emeritus.

My initial meeting with the group happened when my chemistry teacher at Mendell High School arranged for us seniors to visit Northwestern University. There, the NSBE chapter members, all engineering students themselves, told us about their course work and their career prospects.

I was impressed by their enthusiasm for the school, for the curriculum, and for the NSBE as an organization. They were certainly strong role models, and I came away feeling that going to college would be a good experience and that I would have ample opportunity to apply my learning afterward.

I went on to get my B.S. in electrical engineering at the Illinois Institute of Technology on an AT&T Bell Laboratories scholarship; it wouldn't have been possible without that financing. Then I went to the Georgia Institute of Technology for my EE master's.

At graduation, Bell Labs offered me a job at Indian Hill, in Naperville, Ill., and I spent several satisfying years there as a member of the technical staff working on the 5ESS electronic switch project. This led to work on real-time network software, and I collaborated with operating company engineers on developing intelligent networks.

An offer to join Pacific Bell grew out of these contacts. I joined the company in 1987 and am now director of the Information Technology Engineering Consulting Group in San Ramon, Calif. Our role in this group is to support the regional business units of Pacific Bell by conducting information technology studies and developing specifications for new technology strategies. We also develop new product concepts.

Sometimes people ask me what it's like to be a black engineer in a predominantly white profession; how do I cope? Initially, it was something of a challenge. I had to make the transition from a university setting to a work environment, and I had to adjust to a bicultural experience—one culture by day and another at night. But I soon found that there is a sense of support in an engineering environment, that engineers tend to work together.

My personal experience has been positive, not only as an engineer but also as a manager. I think this is partly because I value diversity. While at Bell Labs, I experienced a powerful revelation; my work there exposed me to diverse cultures, many from outside the United States, that I simply did not know about when I was growing up. I came to appreciate how these differing perspectives helped us solve problems faster and more effectively.

Of course, I've heard stories of frustration from black professionals at other corporations—complaints about dull jobs, lack of acceptance, and the inability to get ahead. My perception of why blacks, Asians, Hispanics, and females run into such problems is that management is ineffective in addressing issues, relying on negative stereotypes rather than positively valuing diversity. If managers were more effective in coaching and mentoring, employees would have more opportunities that would lead to equitable career development, independent of the individual's background.

Something we all have to guard against is thinking in terms of stereotypes. The cover story in the winter issue of *The Bridge* sticks in my mind; the NSBE sends the magazine to precollege students to excite them about engineering and encourage them to enter the profession. "Racial harmony begins with you," the cover blurb said. The article, "Stereotypes: The Beginnings of Prejudice," drove home the idea that stereotypes not only divide people, but, worse than that, they create a mindset that hinders progress for all.

This idea can be developed even further in an industrial setting. How often one hears marketing people criticizing the engineers, the engineers criticizing the lab, and buyers criticizing suppliers. The criticism always invokes stereotypes like the "overaggressive" sales rep, the "nerdy" engineer, the "ivory tower" researcher, or the "unscrupulous" vendor. My belief is that in the '90s, U.S. industry will have to face the challenge of fostering teamwork and cooperation. The best way to do this is to accept and value diversity among people and among functional organizations. *—Louis S. Hureston*

Besides these ongoing efforts, today we also support the California Academy of Mathematics and Science, a unique high school intended to increase the number of women and minorities interested in pursuing math, science, and engineering.

We participate, too, in several other precollege education ventures. For example, our desire to make a measurable difference in kindergarten through twelfth-grade education has led to the Hughes K-12 collaborative partnerships with schools throughout southern California.

We have developed partnerships with historically black colleges and universities and other minority institutions. We also contribute hundreds of thousands of dollars every year in grants and scholarships to minority engineering programs.

How well have we succeeded in attaining our goal of diversity? We don't know yet; obviously, we need some kind of measurement system, and we are now defining what the measures should be. By one standard, the ethnic, gender, and racial mix of employees, we've certainly made progress. Women constitute 36 percent of our workforce, and minorities, 33 percent. These percentages are much larger than they were 10 years ago, and we've achieved them despite a truly difficult economy and continued downsizing.

Diversity, however, is not a replacement for equal employment opportunity or affirmative action; it is an extension. The complexity of these programs goes far beyond bottom-line numbers, though numerical goals are clearly an effective measurement tool.

It will take time to answer such questions as: are the numbers distributed among all levels of management and responsibility? How harmoniously and creatively do diverse elements work together? Do we evaluate performance in ways that let us draw on the special strengths of employees with different cultural backgrounds? Acting on these answers will also take time, but we knew at the outset we were in this for the long haul.

To any company, large or small, that contemplates implementing a diversity program, I would offer one key recommendation: make sure top management is fully committed to diversity and will take a leadership role in implementing it. No company, regardless of its size, can be successful in this area unless executive management states emphatically its commitment to change and to a workforce diversity program.

A case in point is Malcolm Currie's address to the first joint meeting of Hughes employees' networking organizations in Los Angeles on Aug. 8, 1990. Currie reminded everyone that Hughes's products, as marvelous as they are, are transitory. "Our real strength, our competitive edge, and what we

The individual is important

Michael H. Conroy, AT&T Bell laboratories

Engineering was an easy choice for me. I liked science, I wanted a professional career, and I knew that engineering promised a good income after only a few years of study—less than for medicine or law. Also, the title "engineer" carries a lot of prestige in Latin America, more than it does in the United States.

My high school years were spent in Caguas, Puerto Rico, where I was born. When it came time to pick an engineering school, I opted for the Florida Institute of Technology (FIT) in Melbourne mainly because it had a four-year BSEE program and a strong electronics orientation. The University of Puerto Rico, on the other hand, had a five-year program and emphasized power.

FIT also offered a Ph.D. program, which I figured would be an advantage if I decided to go into graduate school. As it turned out, I did stay at FIT on a teaching assistantship and eventually got my doctorate on a Ford Foundation fellowship.

I started at FIT in 1970. It was a painful transition for me. I had to adapt to a new language, a new culture, and a different climate. Northerners may think central Florida is balmy, but we never had to worry about frost harming the citrus crop in Puerto Rico, as people do in Melbourne.

Language was certainly a challenge because I had to become fluent in English fast. On the island, I had gotten only a smattering of English, just like kids who study a foreign language in the States. I had learned the King's English pronunciation in school, but when I first heard people speaking in Florida, I thought, "What are they saying?" They skipped so many syllables that their words were unintelligible to me. (We do the same thing in Spanish, of course.)

What made the language barrier more serious was that it could have had an impact on my grades. I remember one quiz in physics that had a problem focusing on a freight train's caboose and when the caboose might be hit by another train. I didn't know what a caboose was, but I figured it must be an important part of the train and therefore either at the beginning or the end.

So I answered the problem in two ways: one, assuming the caboose was at the beginning of the train, and the other, at the end. The professor was impressed that I had analyzed the problem so thoroughly. Little did he know that I had improvised to come up with an answer and not lose credit.

Cultural adaptation was also tough. Everybody complains about college cafeteria food, but I saw foods at FIT that I didn't even recognize. Other students would say, "Well, it tastes different at home," but I didn't even have that reference.

More seriously, the biggest shock was going from a close-knit Hispanic community to the individualistic American culture. I had thrust myself into a very competitive environment where the emphasis was on the individual rather than on the team or the group.

But all of my adapting, thriving, and surviving, I think, helped me later in my career as an engineer and a manager. Today I speak (and think) English as easily as I do Spanish, and I understand American individualism. However, I haven't forgotten that I come from a culture that believes in working together as a team and is more interested in winning the game than in the individual scores.

That trait has influenced my professional life. As an engineering manager, I have been able to build teams more effectively than some of my colleagues. For me it comes naturally; I would not do it any other way.

After graduation, I accepted employment with AT&T Bell Laboratories in Naperville, Ill., near Chicago. I've been working in switching ever since, first in design and now as switch product manager for the international 5ESS switch. My group advises marketing, sales, and customers; we're the ones who know our products best.

In working as a manager, my assignment most recently has been in the Central and South American markets. Since I know the language, the culture, and the technology, it has been fairly easy for me to access the highest levels of telephone companies and ministries. When special attention is shown, the customer feels, "I really do matter; I'm not just an account, just a number of telephone lines, just a $20 million proposal. I'm an individual to AT&T."

Another managerial plus, I think, is the ability to accept more than one view, more than one language,

will do in the future lies in the minds of our people,'' he said.

And he continued, pointedly, ''This is why the release of human possibilities of all our people must be our highest and never-ending activity. It must be worked at and cultivated. And it's important that all levels of supervision and management understand this.'' It was important that Hughes not concentrate on numbers alone, he said. It was time to go beyond affirmative action; it was not enough to simply affirm the notion of equality of opportunity.

Once this commitment is established, the first thing a company should do to implement a diversity program is to develop a mission statement and objectives so that all employees have a clear vision of where they are going. To determine where improvements need to be made, a company must also collect data internally.

Many other activities should follow. Examples are: setting up awareness training for management people; identifying specific processes that affect career growth and development and evaluating their effectiveness; and developing measurement tools and management accountability systems.

Some further advice is: use a variety of media to get the message across—and to receive messages. At Hughes, we report on diversity efforts and results in *Hughesnews*, our employee newspaper. We also produce videotapes that address various issues in a diverse workplace, and our executives meet with small groups of employees to learn their feelings and perceptions. And we take full advantage of the two-way communication that our employee network groups provide.

The greatest asset our company has is the talent and energy of its employees. We recognize the need to use and develop the skills of all employees, while helping them achieve their career goals on an equal basis according to their contributions and performance. We believe that a diverse workforce helps us meet our business objectives and increase our productivity. To us, commitment to diversity is a fundamental management philosophy that is an integral part of the company's overall operating strategy.

more than one culture, and more than one way of solving a problem. This flexibility gives a person a definite edge over those who do things in a monolithic way. In my own case, having accepted a second culture—Anglo-American—I found it easier to accept a third—Asian.

The experience learned in adapting to a new culture also makes adapting to new technology easier. I think that has helped me stay current and will allow me to avoid the fate of succumbing to technological obsolescence.

Another advantage I have had that has helped me as a manager is my Hispanic background. Before discussing any business, Hispanics ask, ''How are you?,'' and they really want to know. And the next question almost immediately is, ''How is your family?'' Hispanics are sincerely concerned about the welfare of a colleague's family—healthwise and otherwise. Only then are they ready to conduct serious business.

But those preliminaries make good business sense. An engineer who is preoccupied with family worries is not going to work as productively as he or she otherwise would. That's why I spend time with my team as often as I can and try to develop personal relationships with them. Often, I can help them adjust their work schedules so that they can tend to pressing problems or illness at home. ''What are you doing here?,'' I said to one worried parent. ''Why aren't you home taking care of your sick children?''

On the subject of diversity in general, I think we are extremely lucky in the United States to have such varied people resources. With 25 million Hispanics, we are the fifth largest Spanish-speaking country in the world.

If we develop a proportional number of Hispanic engineers and managers, we can relate to technological markets in Mexico and Central and South America. Similarly, black engineers can help us relate to the vast potential markets in Africa, and Asian engineers can help to make us more effective in the Pacific Rim and India. —*Manuel Figueroa (M)*

Forums for diversity

Ethel Batten
Head, Diversity Department
AT&T Bell Laboratories

Here at AT&T Bell Laboratories, our technical staff has nearly reached the level of demographics predicted by the Hudson Institute report *Workforce 2000*. Our engineers and scientists are from everywhere in the world.

You can walk throughout the halls and see different cultures represented by various forms of dress. You will also see people with physical disabilities. Why is that? Because through our recruiting process, we look for the best and the brightest, regardless of race, lifestyle, or physical challenges.

However, most of the diversity is not yet at the executive or managerial level. And that can be a problem: if managers don't feel comfortable with the differences among the technical staff, then even subconsciously they tend to hire and give opportunities only to people like themselves.

I am not speaking about only traditional white males. We have some groups headed by Asians that have a dominant Asian composition, where the white male in the group is the outsider. Or a young department head may be looking for workers who are ''innovative'' or ''creative'' or who have ''young blood,'' and older employees may not be selected for that group, which then loses out on their experience and wisdom.

From the company's viewpoint, diversity is an issue of quality: using all your resources—especially people—to their full potential, including all their unique and different points of view and skills.

Moreover, people are more productive if they're comfortable at work—if they feel they can be open and honest. One example of such candor is sexual orientation. It's natural that on Monday a colleague might ask me: ''What did you do this weekend?'' I might say: ''My husband and I planted bulbs.'' But what about the gay person? He or she might say: ''My friend and I saw a play,'' and avoid mentioning the friend's gender to fit in with heterosexual expectations.

This person, if not comfortable with colleagues, may be the one who always comes alone to the company picnic, who has no pictures in the office, and who is always busy when invited with family to dinner. Colleagues, in turn, feel the distance and treat the gay person like a loner.

Thus he or she becomes the outsider. And that can translate into fewer opportunities in the person's career—because a lot of work gets done at the lunch table and at social or informal settings.

Keep in mind, merit in work is sometimes a result not only of competence, but also of opportunity. If this person has fewer opportunities and promotions, then the company loses out on the full use of his or her talents. Some of this we find out during exit interviews. But it's more important that we get driving instructions while we're driving, not after a collision. I want people to tell me how they feel while they're still here.

Another area where the company gains a competitive advantage from a diverse workforce is customer service. As companies become more global, their customer base is becoming more diverse. If we can utilize the skills, backgrounds, language, and culture of the people in the company, we can better meet the needs of the customers.

For example, after the dissolution of the Soviet Union, AT&T was looking immediately toward proposing some communications systems in Ukraine. We had a number of people from Ukraine here at Bell Labs, and they became advisors to the marketing or-

ganization. Even here at home, AT&T has begun to see real gains in sending Hispanic sales people into Hispanic neighborhoods.

People with differences want to be asked for their views because their cultures are important to them. We have to be conscious of differences in our planning. To cite an instance, we don't want to schedule a major meeting or company picnic on Chinese New Year or on Yom Kippur or on Hindu New Year, any more than we do on Christmas.

All of our survival depends on managing relationships: at work that means relationships with our bosses, our subordinates, and our colleagues. Feeling comfortable with differences in people comes only through understanding them. We're encouraging that understanding in two ways: by soliciting the views of diverse groups for strategic planning and corporate policy, and by supporting certain extracurricular cultural events to help everyone appreciate and value the differences between people.

The oldest, largest, and probably most influential diverse group here is the Black Technical Managers, which includes techni-

cal supervisors, department heads, directors, and executive directors throughout the technical organization. Its counterpart, representing the nontechnical managers, is the Black Administrative Managers.

Another group is the Asian-Americans for Affirmative Action, representing the Asian and Pacific Island populations of Bell Labs. Our Hispanic group is the Bell Labs chapter of the national organization Hispa, and the Native American Club represents the American Indians in all of AT&T. Also active is a group called League (Lesbian and Gay United Employees). Although League was formed at Bell Labs, it has now become a nationwide organization and held its first national conference this past February in Florida.

Among Bell Labs' disabled employees, the hearing-impaired subgroup is especially busy. This year we're having workshops for managers who have hearing-impaired employees, teaching them how to deal with the deaf culture. We're also holding workshops for hearing-impaired employees to help them get the most out of being a corporate citizen and working here. On staff we also have two sign-language interpreters, one in Indian Hill and one in South Jersey. And this year one of the things we are enhancing is the access and mobility needs of our wheelchair-bound employees.

We encourage all these groups to be aware of one another by holding Diversity Day at the various Bell Labs sites. The groups all come together and set up tables with brochures. Highlighting the day is a meeting in the auditorium to talk about diversity, legislation, and other work-related issues.

One reason for such get-togethers is that many of the issues these employees face are generic to all. Thus, we are planning to set up a permanent intercouncil of the different groups. From that, we hope to learn what issues need to be addressed by training and education to get people away from doing unproductive things. After all, bigotry, chauvinism, and racism are all unproductive.

In addition, Bell Labs encourages the observation of various cultural activities, which can range from serious to lighthearted. Usually they're held during lunchtime. For example, during Women's History Month, we had a couple of female Nobel Prize winners come in as speakers. During Black History Month, our opening keynote address was given by William H. Gray III, president and chief executive officer of the United Negro College Fund Inc. We also had a display of attire for African women and a concert by the Harlem Boys' Choir. And during Asian Heritage Month, we had art work displayed and performances by Asian

Raising the gross national spirit

Many native Americans entering an engineering college or university today find themselves in a disquieting situation on two fronts. First, their technical background is likely to be inadequate owing to poor preparation in Government-run reservation schools or in many inner-city schools. Second, there are significant differences in the value systems of the indigenous cooperative culture and the western competitive culture.

As a Hopi removed one generation from Government schools, I was fortunate enough to receive adequate technical preparation for my undergraduate work in the late 1950s. I earned a B.S. in mechanical engineering from California State Polytechnic University (1961) and an M.S. in mechanical/control systems engineering from the University of Southern California (1966).

Nonetheless, I was still disquieted by the gap in the value systems—a gap that still exists today. The difficulty arises not, as past U.S. government policy has assumed, because native peoples do not have the intellectual capacity or cognitive ability to learn. It emerges because, at the root, native peoples have a life ethic that differs from today's competitive western world. That ethic emphasizes family, knowledge of tradition and self, understanding of the individual's relationship with the Creator and the land, sharing with others, and the wise use of resources. Fundamentally, our people still believe they are keepers of the land, stewards for generations, not exploiters of resources for short-term gain.

Only very recently—in the 1970s—did the Federal government adopt a policy of self-determination for native peoples rather than relying on paternalism and cultural absorption. Among other things, self-determination, which we had adopted for ourselves generations earlier, means governing our own destiny, including developing the physical and personal infrastructure of the tribes. Such development has created needs for leaders, engineers, scientists, doctors, lawyers, and businesspeople.

In the past two decades, native Americans have begun to focus on creating the infrastructure to encourage and train young people for entering professions—like engineering and science—that were seldom considered or encouraged by the culture of Federal government schools. But the highly specialized and secular European style of education used in teaching these professions is different from the more holistic and spiritually conscious native American cultures.

As a native American, a Hopi, I take a holistic approach to life. Our ancestors did not set boundaries separating traditional forms of engineering, science, art, and the spiritual Creator-centered life. Even today I find myself freely shifting back and forth among these areas.

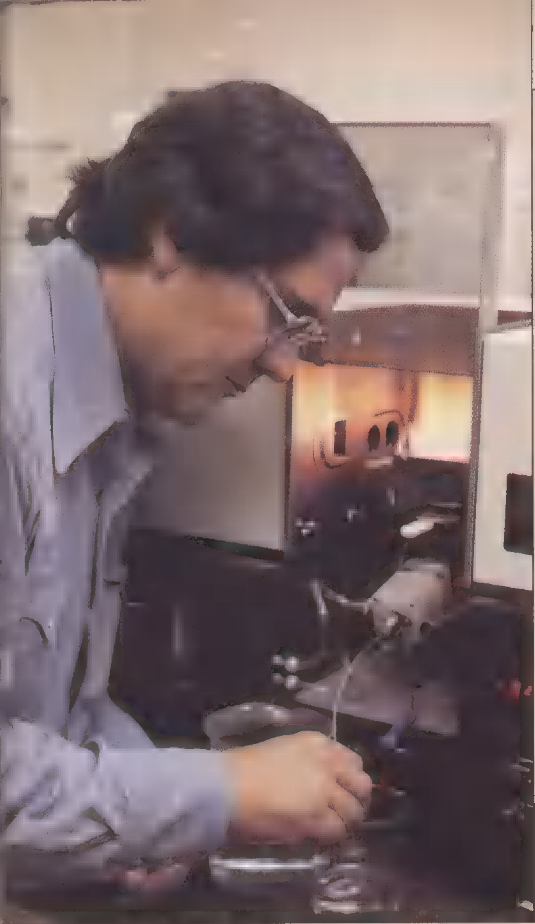
For the first 10 years after receiving my degrees, I was an engineering specialist and a project engineer at Litton Guidance and Control Systems in Woodland Hills, Calif. There, I designed and developed inertial measurement units and star trackers for military and intercontinental commercial aircraft.

The next 18 years, I worked on creating and managing the Environmental Department at the Salt River Project, a power and water utility serving Phoenix, Ariz. The emphasis there was placed on sensitivity to the environment and to people when siting large coal-fired power plants, railroads, dams, and other projects.

During this time, however, I was also highly influenced by my aunt Elizabeth White, who taught me the philosophy and art of making pottery. In 1990, I left industry to pursue an artistic career and community service. Now I provide technical and political assistance to my Hopi tribe on coal mining and mineral resources.

I have also helped to set up two groups that are aimed at helping young native Americans find their way in technical fields while retaining their cultural traditions. One, which I co-founded in 1977, is the American Indian Science and Engineering Society (Aises). Now based in Boulder, Colo., the 2000-member society is dedicated to increasing the number of American Indians in science and engineering and to developing Indian leaders.

Aises has mentorship programs, interactive tutoring, several hundred annual scholarships, and 81 student chapters in the United States and Canada. Although the students in Aises represent 250 tradi-



Jerry D. Jacka

tional tribes, they have a common spiritual tie and a tradition of honoring one another. Supported by the Indian community, by donations from corporations and foundations, and by grants from Government agencies, including the National Science Foundation, Aises works to give young people the opportunity to lead major projects.

The society originally started as a college-level organization to encourage native Americans to enter technical careers. But we've found that even high school is often too late: young people gain or lose their academic motivation around age 12 or 13. So now we're looking at ways to open up the pipeline by reaching students as young as those in grammar school (and their parents as well).

Through Aises, we're also working with young people to show them they do not have to lose their Indian heritage to enter the professional world. On the contrary, there is much value their holistic background can bring to engineering and science.

To encourage such thinking, every November since 1979, Aises has held a three-day national conference; 1991's had more than 3000 attendees and over 100 exhibitors. Unlike most technical society meetings today, the hallmark of Aises meetings is prayer and blessings, part of our ancient traditions.

Our students have called for additional orientation in their cultural values or traditions while learning technical fields. One organization that can meet that call is the Institute of American Indian Arts, which a number of us founded in 1988 in Santa Fe, N. M. At present the institute is a two-year accredited college with about 50 faculty and staff and more than 250 students. It teaches all the arts, computer graphics, and film-making, and is opening a new museum in downtown Santa Fe this June.

Now being planned is a campus on a 140-acre site in Santa Fe, with a first-phase vision of a four-year college or university for 1000 students, with integrated studies of architecture, science, the environment, business, and liberal arts.

Eventually, the Institute's emphasis will be on providing national and international students with a holistic education, focusing on ways to meet the vision of renewal and rebirth for all native peoples of North, Central, and South America. Its aim will be to revitalize and honor each tradition and language, and to emphasize the wholeness of the family, the sanctity of all living things, and the healing of the earth.

At Aises's annual meeting last year, our young people affirmed their greater concern for North America's gross national spirit rather than for its gross national product.

Both Aises and IAIA give us new hope because they represent not only technical grounding but also the rebirth and continuation of our past civilization, even in today's materialistic and energy-consuming Western civilization. Our traditional value system helps keep people whole. And it's one that I expect our young people will apply in the workplace and in their positions of leadership.

—Alfred H. Qöyawayma (M)

dancers.

All the functions put on by these diverse groups are funded by Bell Labs. The groups apply for funding from my diversity department, listing and describing what they plan to do during the year and how much money they want. We on the committee look at the funding request and either grant it, trim it, or do what is needed.

Awareness training programs are also in place to educate employees to recognize and respect the value of human differences. Some of these programs include workshops like "Gay and Lesbian Issues in the Workplace," "Women and Men in the Work Environment," "Managing Diversity," and "Minority Workshops for Asians/Blacks/Hispanics in the Corporate Environment."

To better understand how effectively Bell Labs uses minorities, women, and people with disabilities, we have started a program of utilization analysis to compare work experiences in hiring, promotions, salaries, and performance reviews.

The success of all these programs is measured through questionnaires, asking employees and customers their reactions about the value of the activity and whether or not it will enhance our ability to value diversity. Thus we can summarize the data at the end of the year and provide the technical organization with some kind of metrics about how it was received, which ones had the greatest impact, and whether we should do it again next year.

We also communicate with people in equivalent positions at other companies. Just recently, we finished a competitive benchmarking exercise. Visiting five different companies, we looked at what they do in this business and how they do it and compared it to what we're doing here.

More commonly, people call us wanting to know how our groups got started, how are they funded, and how Bell Labs works with them. Also, I conduct workshops during the fall and spring at historically black colleges and colleges that have a lot of women students. I also work with high schools and inner-city groups such as Inroads and Aspira. From these activities, I see what is going on in many places.

The best signal I get from this work is that companies are beginning to see diversity as a business issue, not just a moral issue. Being a second-class nation is not what any of them want. We want to be No. 1. We want everybody to be utilized. That means we have to understand what issues impact everybody.

Making engineers feel at home

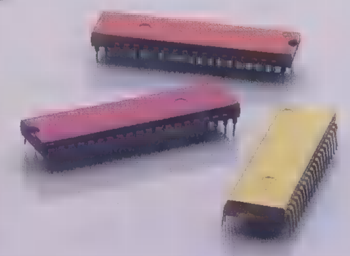
Sharon Richards
Intercultural Program Manager
Intel Corp.

Intel Corp.'s intercultural training for employees goes back to 1983, when a group of senior managers saw a need to support foreign-born engineers—primarily Asians at that time—by helping them understand and adapt to U.S. culture. The senior managers instituted our "Multicultural Integration Workshop," a one-day session where newly hired professionals get together with managers to identify the cross-cultural issues in the workplace that affect them directly. The managers strive to provide the newcomers with role models and help them with career planning. Perhaps most importantly, the workshop gives these employees an informal environment for meeting people and making contacts.

Still the keystone of our intercultural program, the workshop is now augmented by courses on American business culture, accent improvement, speaking under pressure, American idioms and vocabulary in the workplace, and technical and business writing.

The accent improvement course, for example, recognizes that foreign-born employees often have a good command of English vocabulary and structure but find that colleagues have trouble understanding them. Participants practice the sounds, rhythm, stress, and intonation of American English. We promise students that they will speak more clearly and confidently in person and over the phone. We follow up with a maintenance program in which students practice prepared presentations and extemporaneous speech; the maintenance course can be taken several times.

Speaking out runs counter to many Asians' cultural norms; it is considered boastful



We also coach foreign-born professionals in making effective oral presentations, as well as in writing with clarity and precision. Our idioms and vocabulary course introduces 200 common American idioms; we teach techniques for vocabulary building, read the news together for current usage, and present phrases for speaking smoothly.

Foreign-born professionals have joined in these courses enthusiastically, and we in the program are hard-pressed to keep up with the demand for them.

At the same time, the program has expanded in another direction: helping U.S.-born engineers understand and adapt to other cultures. One aim is to enable them to work effectively and productively in our U.S. facilities with people from diverse backgrounds, and in our international sites as well. We want them to be aware of and sensitive to local customs, courtesies, and business practices.

In an intensive all-day session, for example, managers learn how people from four different cultures approach problem-solving, conflicts, work relationships, time management, and information exchange. They hear their fellow employees' views about what it's like to work at Intel and what it's like to be foreign-born in an American work environment.

A topic that is cited often is speaking up, which is regarded as countercultural by many people who come from Asian cultures. It's seen as boastful bragging, tooting your own horn. Yet, for all of us, accomplishments and achievements need to be known in the workplace; that's critical to success in the work environment. It's also no less important for the company to have the benefit of our ideas, even if they seem to contradict or compete with those of others. So we try to develop practical techniques of communication whereby frank discussion is encouraged and diffidence is overcome for the sake of solving common problems.

Another session, ''Managing in a Cultural Environment,'' gives the managers first-hand experience and suggests strategies for building a multicultural team. Managers get feedback from our ''Multicultural Integration Course,'' too, when appropriate, as to how they can best support and guide those who report to them.

But a bigger aim of the program derives from Intel's international presence and involvement in joint ventures around the world that deal with customers and suppliers abroad. To expand our management competency globally, we offer culture-specific training classes for engineers who are on assignment to—or who interface frequently with—Japan, Korea, Taiwan, Malaysia, the Philippines, Ireland, and Israel. Another group called ''inpatriates''—employees from international sites who are on assignment in the United States—are also given both intercultural and country-specific training as part of their relocation.

For example, ''Intel-Ireland Interface'' is an eight-hour session in which participants learn about U.S. and Irish cultural differences and how they affect business communication styles and practices. Another, ''Japanese Culture/Language,'' comes in three segments that, combined, give 132 hours of training in such practical activities as making appointments, describing events, and requesting items and services. Along with that, students learn about Japanese values, norms, and communication style.

In all our training, we point out that our goal is to help participants acquire insights and skills that can enhance their professional development, and that we're not encouraging them to give up their core values or their cultural heritage. Inpatriates often ask me, ''Do I have to give up who I am to be successful in the American environment?'' Not at all.

What we do recommend is that people—both expatriates and inpatriates—acquire a repertoire of skills that will help them to work in multiple environments. In our classes, we refer to that battery of skills as ''style switching.'' On a rainy day, for instance, you put on a raincoat, but that doesn't mean you wear it all day long. We wear our most comfortable jeans and T-shirts to a picnic; we wear more formal clothes to a graduation dinner.

I think the most valued part of our training is presenting to the students successful men and women who represent diversity. They talk about their career paths, their accomplishments, and the hurdles they cleared. They convey their own personal perspective and the message that, at Intel, you can take initiative; you can make things happen.

Single-minded striving

My father always wanted each of his daughters to become a professional—a doctor, a lawyer, or an engineer. I was supposed to become an engineer—and I did. In Vietnam, where my family comes from, engineering is regarded as one of the most prestigious professions—more so than it is here in the United States.

My family left Vietnam in April 1975, when the Thieu government was falling and the Viet Cong were taking over in the south. My mother brought me, my four sisters, and my brother to the United States with exactly US $100, while my father stayed behind to try to secure at least some of our savings. We had to get out fast, but our money was tied up in the bank. He wasn't able to rejoin us for another two years, and he could bring nothing with him.

My mother settled us in Houston, Texas, and we proceeded to acclimate ourselves, enrolling in the local schools. I went down one grade, but after a year in sixth grade at Gordon Elementary School, I skipped the next three grades. I graduated from Alief Hastings High School in 1979 as class valedictorian—not bad for a 16-year-old girl who spoke no English four years earlier.

Even though my parents encouraged me to study engineering, I considered studying mathematics in college. I loved math in high school and got good grades in trigonometry and calculus. But when I thought carefully about it, I realized that engineering offered a more financially rewarding career—one that would be profitable sooner than mathematics would be. I'll never get rich in engineering, but it does provide a good income. One of my goals, too, was to help my parents as soon as possible.

After I received my BSME from the University of Texas in Austin in 1982, Texas Instruments Inc. offered me a job in Houston. I was eager to work in Houston because I would be close to my family. At the same time, at 19, I wanted to be independent and rented my own apartment in the neighborhood.

My first assignment at TI was working on defect analysis of manufacturing software for dynamic RAMs. At that time, a 64M-bit memory was state of the art; I worked on schematic verification to ensure an error-free manufacturing tape.

Two years later, I joined the 1M-bit dynamic RAM project. While our supervisor was in Japan working with TI's wafer fab there, I coordinated the team effort in Houston. Later I myself spent nine months in Japan, interfacing with the wafer fab and debugging the chip through several revisions.

In the meantime, I was also taking night courses at the University of Houston, where I received my MBA in 1989.

My work at TI continued to focus on enhanced versions of the 1M-bit dynamic RAM. At one point, I gave design tutorials to engineers at TI sites in Japan, Singapore, and Italy.

Starting in 1989, I led a small team to study the feasibility of manufacturing TI's first biCMOS 4M-bit dynamic RAM. This was to be a superfast chip, with an access time of 35 ns. We evaluated market demand, the progress of competitors, and resource requirements. Then we actually designed the chip, drew up a proposal, and presented it to top management.

Currently I am section design manager for 16M-bit-wide input/output dynamic RAM devices. These are application-specific memories, and so far we've designed a device with over 200 possible options.

A team of nine engineers now reports to me. We work closely with the manufacturing people, with

Preparing for responsibility

Thomas J. Smith
Director, Human Resources
Computer Sciences Corp.
Integrated Systems Division

Computer Sciences Corp. (CSC) manufactures no equipment—only ideas. In the Integrated Systems Division, we integrate large systems, mostly for the U.S. government. Our products are complete "megasystems," with all the hardware, software, communications, training, and initial operation and maintenance that go with them. We choose from a variety of hardware and software suppliers to obtain the best solution for a system problem.

To develop our megasystems and put them together, we need many systems engineers, programmers, and communications experts; about 80 percent of the division's staff is highly technical.

Our technical people have such titles as systems analyst, systems engineer, computer scientist, network engineer, office automation specialist, telecommunications programmer, and scientific real-time programmer. They are educated in computer science, mathematics, electrical engineering, physics, and related fields.

We also need managers—people who can coordinate and direct the work of these professionals. In fact, much of our future growth will depend on the success of managers. We found that, as we captured new business, the same names kept coming up time after time as candidates for the project managers' positions. This meant we were continually placing a heavy burden on the same people—and were not developing new people for new business.

To remedy that practice, our division president, Gary Bard, conceived the idea of placing deputy managers under a project manager. The deputies would assist the project manager and accept gradually increasing responsibility. In a year or two, they would be ready to manage a product of their own.

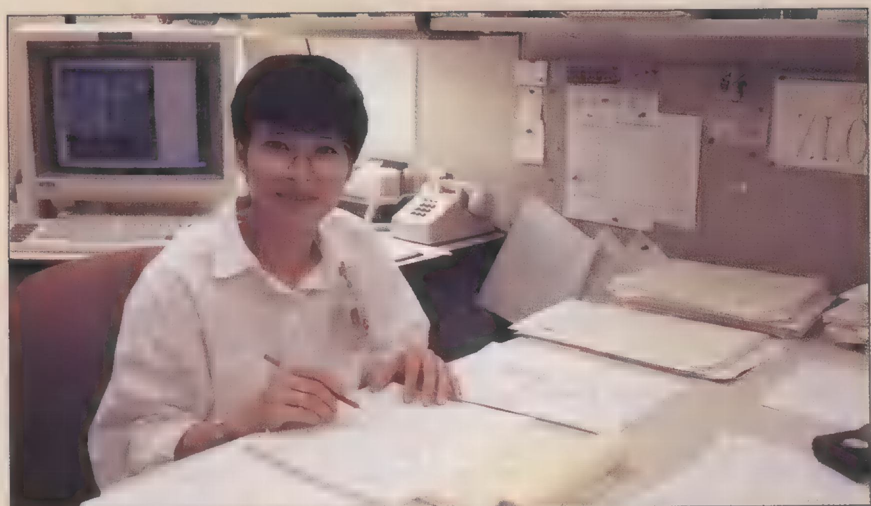
Now, every year we select about seven middle-level managers who show promise. We put them on a fast track and make sure they have frequent contact with the division president and various vice presidents, all people whom they would ordinarily be unlikely to meet. The intent is to encourage middle-level managers and vice presidents to develop mutual trust as the middle-level people mature in responsibility.

Our experience with this program has shown that several advantages accrue from it. First, it provides a route for women and minorities to advance. Our technical staff now consists of about one-third women and 12 percent minorities. We expect the proportions of both groups to grow as *Workforce 2000* predictions materialize, and we want our management as well as our staff to reflect that makeup.

Second, it signals the rest of the workforce that their contributions are equally important and they are not forgotten. When all employees see that selections are based on demonstrated skills and abilities, management will establish credentials for fairness.

Third, we believe that the deputy manager policy will reduce turnover, which can be high in our business. Our employees' skills tend to be highly portable; they can pick up and move almost anywhere they choose, especially in good economic times. We want to retain our good people, and we believe that by showing opportunity for advancement and offering visible recognition, we can do that. We want to show that, even though people may not be immediately promoted, we are concerned about them, their progress, and their future.

Fourth, and most important from a business standpoint, CSC is developing a cadre of experienced, skilled, highly motivated managers drawn from the best that diversity has to offer. When a suitable project comes in, they can take charge immediately—and so far, about a dozen people have done so with outstanding results.


Ben Simusz

marketing and product engineering, and sometimes with the customers directly. When a problem crops up, we determine whether it's in the process or in the design.

I feel that I have a good relationship with my team and that we work reasonably well together. If I have a complaint, it's that they are too tall! I have a hard time keeping up with them when we walk along the hall, and I certainly couldn't join them in an impromptu baseball game. But my small stature doesn't stop me from joining them in a local pub occasionally to celebrate an accomplishment—or to commiserate over a problem that seems intractable.

I know that I work too hard. I used to work till I dropped, almost. I could work through the night; when I'm working on a problem, I get hooked on it. People have told me I'm "uptight," but I care about my work and I expect the same level of care in others.

These days, I'm trying to be more relaxed. But even when I go home, say at nine or ten o'clock at night, I sometimes feel guilty. Dinner is ready, everything is in order, and my husband has been waiting for me. On the way home, I will often stop for some Hagen-Dasz as a little peace offering. It's easier for a man; he might work that late and not feel guilty because it's traditional for him to put in long hours.

My husband is understanding about it, of course. He is an engineer, too, and he kids me, "If I worked as hard at my company as you do at yours, I'd be a vice president!" We want to start our own family soon, and then I *know* I'll have to limit my work more strictly. —*Duy-Loan T. Le (M)*

TO PROBE FURTHER. *Workforce 2000: Work and Workers for the Twenty-First Century*, by William B. Johnston and Arnold H. Packer (Hudson Institute, 1987), examines the forces shaping the U.S. economy, proposes three scenarios for turn-of-the-century economics, and predicts the demographics of the workforce of the future. It can be ordered from the institute, Box 26-919, Indianapolis, Ind. 46226; 317-545-1000.

Donna E. Thompson and Nancy DiTomaso survey the problems of minorities in management and suggest solutions in *Ensuring Minority Success in Corporate Management* (Plenum Press, New York, 1988).

DiTomaso, George F. Farris, and George C. Gordon give early results of their diversity research in "Managing Diversity in R&D Groups," *Research-Technology Management*, January–February 1991, published by the Industrial Research Institute, Washington, D.C.

The Second Annual Diversity Conference, May 27–29, 1992, Washington, D.C., offered

Singapore: diversity in microcosm

Perhaps no country has a greater racial and cultural diversity in its population than Singapore. Yet with a per capita gross national product of US $13 600—larger than that of many European countries—the small city-state enjoys a prosperity neck and neck with Hong Kong's and exceeded only by Japan's and Brunei's in Asia. Its peoples work together for their common good, encouraged and closely controlled by the Government. Its efficient roads, port, and telecommunications are famous.

Of its 2.7 million citizens and permanent residents, 77 percent are ethnic Chinese, 14 percent are Malays, and 7 percent are Indians (including Pakistanis, Bangladeshis, and Sri Lankans). The balance consists of Eurasians (largely descendants of Portuguese colonials), Arabs, Armenians, and Jews.

Multiracial, polyglot, multireligious—Singapore accepts diversity as a way of life

To these must be added more than 300 000 temporary residents: North Americans, Europeans, and Japanese from the multinational companies whose investments fuel the island's economy; "guest workers" admitted from Malaysia, the Philippines, Thailand, and other countries as construction and factory workers and domestics; and foreign students, many of them attending Singapore's cosmopolitan Institute of Southeast Asian Studies.

These residents—along with 5 million foreign tourists a year, ships' crews and passengers in the busiest port in the world, and those in transit at Changi Airport—make up a polyglot lot.

To communicate, these Singaporeans can choose from not one, but four official languages: Malay, Mandarin Chinese, Tamil, and English. Other Chinese dialects spoken are Hokkien, Teochew, Cantonese, Hakka, Hainanese, and Foochow. Indian languages, besides Tamil, include Telegu, Malayalam, Punjabi, Hindi, and Bengali.

English is the medium of instruction in schools and the language of administration, courts, and big business. English is also a *lingua franca* for hundreds of thousands of people who otherwise simply could not talk with each other. Almost half the population speak at least two languages.

Over eight religions are practiced. Most Singaporeans—59 percent—embrace Buddhism, Taoism, and/or Confucianism. Islam, Christianity, and Hinduism together account for another 32 percent, while Sikhism and Judaism account for a significant minority.

In managing this vast diversity, the Singapore Government actively promotes a common Singaporean national identity while recognizing the importance of its people's ethnic roots. Underscoring that recognition, the Government maintains official links with ethnic group representatives. For example, the Islamic Religious Council advises the Government on matters affecting Muslim citizens and administers the mosque-building program and the disbursement of financial assistance to poor Muslims. Similarly, the Hindu Advisory Board provides a link to the Hindu community.

Groups are accorded special treatment, as the Government deems appropriate. For example, marriages (and divorces) between Singaporean Muslims are carried out according to Muslim law, and so are any inheritance settlements.

Traditionally women in Singapore have worked in lower-level clerical and routine operator jobs in electronics and textile factories. Their salaries have consistently been lower than men's in the private sector, although the Government operates on an equal-pay-for-equal-work basis. Indeed, the Civil Service is one of the major employers of women; more than half its personnel are female.

Women's status in industry may be changing. In keeping with the Government's swing in emphasis to R&D from low-skill, labor-intensive manufacturing, increasing numbers of women are being trained in such technical skills as programming and computer science. Women make up 15 percent of the electrical engineering class at the National University of Singapore.

Indian Singaporeans seem to share less, proportionately, in the country's technological jobs than does the Chinese majority. This underrepresentation may be traced to poor preparation for high-tech careers. In 1989, for example, only 62 percent of 12-year-old Indians passed the national examination in mathematics, compared to 88 percent of Chinese of the same age. The Government exhorts Indian parents to cut back on their children's household chores and television watching in favor of more homework.

The Government is officially committed to diversity. "Tolerance is crucial when peoples of many races, languages, cultures, and religions live together," Lee Kuan Yew, when prime minister, told a gathering of Sikhs. "Singaporeans have by and large accepted diversity as an unchangeable fact of life," he said.

The Singaporean Government is known as a strict one that regulates many aspects of its people's lives, all for what is seen as the greater good of the community. This interventionism is being relaxed, albeit slowly, by a new administration under Lee's successor, Goh Chok Tong. *—G.F.W.*

panels and workshops on such wide-ranging topics as breaking the "glass ceiling," handling white male backlash, and developing conflict resolution skills. For information, contact the National Diversity Conference, Box 978, Danville Square Station, Danville, Calif. 94526-9922; 510-831-0272.

Several engineering organizations provide guidance to members of groups underrepresented in the profession. Among them:

- American Indian Science and Engineering Society (Aises), 1630 30th St., Suite 301, Boulder, Colo. 80301; 303-492-8658.
- National Action Council for Minorities in Engineering (Nacme), 3 W. 35th St., New York, N.Y. 10001-2281; 212-279-2626.
- National Society of Black Engineers (NSBE), 1454 Duke St., Alexandria, Va. 22314; 703-549-2351.
- Society of Hispanic Professional Engineers (SHPE), 500 E. Olympic Blvd., Suite 306, Los Angeles, Calif. 90022; 213-725-3970.
- Society of Women Engineers (SWE), 345 E. 47th St., New York, N.Y. 10017; 212-705-7855.

American Demographics, a Dow Jones & Co. publication, covers changing population patterns. A booklet analyzing the 1990 U.S. census results, "American Diversity," is available. Contact the publisher at 127 W. State St., Ithaca, N.Y.; 800-828-1133.

Human Resource Management magazine (John Wiley, New York) frequently addresses diversity issues that affect personnel professionals. See the June 1990 compilation of articles on diversity in the workplace.

The American Society for Engineering Education, Washington, D.C., publishes *ASEE Prism* in which a frequent topic is encouraging diversity in education. See, for example, "The Missing Piece," September 1991, for an analysis of the complex issues underlying efforts to attract and retain women in engineering schools.

For more on diversity in Singapore, see *Singapore Facts and Pictures 1991*, a compendium of useful information and history, published by the Ministry of Information and the Arts, 460 Alexandra Rd., PSA Building, Singapore 1511; (65) 270 7988. For insight into the challenges Singapore faces, see *Dragons in Distress* by Walden Bello and Stephanie Rosenfeld (Institute for Food and Development Policy, San Francisco, 1990).

ACKNOWLEDGMENTS. Many people cooperated with the *Spectrum* staff on this report. Special thanks go to Michele Bourdon, Intel Corp.; Alok Chakrabarti, New Jersey Institute of Technology; Margarita Colmanares, U.S. Board of Education; Richard Dore, Hughes Aircraft Co.; Robert Ford, AT&T Bell Laboratories; Iris Chin Choo Geddis, Singapore Mission to the United Nations; Dundar Kocaoglu, Portland State University; Debra LaFountaine, American Indian Science and Engineering Society; Ah-Choy Lieu, National University of Singapore; William Pinkston III, National Society of Black Engineers; Betty Prince, Texas Instruments Inc.; Walter Robb, General Electric R&D Center; and Michael F. Wolff, contributing editor. ◆

Rethinking X-ray lithography

New devices that reflect and collimate X-rays seem poised to create a viable alternative to costly, unwieldy synchrotrons

The longevity of optical lithography, using ultraviolet light, has repeatedly shocked and confounded the legions of experts who time and again predicted that the technology had reached its practical limit. Nonetheless, most specialists remain convinced that as feature sizes on circuits become smaller and smaller, the industry will inevitably have to turn to X-rays, and the consensus now seems to be that X-radiation will be required for ICs with features measuring less than about 0.2 micrometer. Before the decade is out, these ICs—including 1G-bit dynamic random-access memories (DRAMs)—are expected to create sophisticated new products and huge markets.

Until recently, most experts probably also agreed that at the heart of these futuristic wafer fabrication lines would be synchrotrons, X-ray sources that are projected to cost between US $25 million and $65 million. With IBM Corp., Motorola Inc., and several Japanese electronics giants all actively pursuing synchrotron-based IC fabrication, and with the cost of a fully equipped facility estimated to be in excess of $100 million, commercial X-ray IC fabrication seemed sure to become the province of corporate giants.

Not so, many experts now say. A viable alternative to synchrotron-based fabrication lines seems to be emerging from a host of recent advances, including more powerful, relatively low-cost point sources of X-radiation and a few intriguing devices to reflect, collimate, and manipulate X-rays. These point X-ray sources will cost a fraction of the price of synchrotrons, and after prototypes are built and proven, chip-fabrication facilities could be built around them in a few years, opening up attractive niches to smaller companies.

"My guess is that the development of [the necessary X-ray reflectors and collimators] is going to get funded, and we're going to have a complete X-ray proximity lithography system that small firms can acquire within three years," said Troy W. Barbee Jr., a materials scientist in the chemistry and materials science department at Lawrence Livermore National Laboratory in Livermore, Calif. Livermore, Sandia National Laboratories, and AT&T Bell Laboratories are among the most active developers of these nonsynchrotron X-ray lithographic technologies.

The attractions of X-ray lithography are not limited to the ability to resolve smaller and smaller features, either. Since X-rays pass through many solid materials—including dust—the clean rooms needed for chip fabrication can be built to specifications much less severe than those needed for optical (ultraviolet) lithography. Chip makers refer to this feature as greater process latitude, and it can mean higher chip yield and thus increased profit.

> Projection lithography with an inexpensive alternative X-ray source has already been demonstrated

The primary source of funding in most of these R&D areas is the Defense Advanced Research Projects Agency (Darpa) in Arlington, Va. The National Science Foundation and the Department of Commerce, both in Washington, D.C., are also funding some work, and the Naval Research Laboratory, also in Washington, is performing some research projects and offering technical assistance on others.

One company, Hampshire Instruments Inc. in Rochester, N.Y., already offers a complete set of equipment for producing ICs with X-rays, including a laser-based point X-ray source and lithography system and all of the necessary wafer-handling equipment. The company's latest system is capable of producing ICs with 0.35-μm features, as opposed to the 0.5-μm features typical of state-of-the-art commercial ICs now produced with ultraviolet lithography. AT&T, Motorola's Semiconductor Products Sector, and Cypress Semiconductor are now evaluating Hampshire's X-ray system, comparing its performance to that of conventional ultraviolet and other lithographic technologies.

Hampshire claims that its latest system can expose twenty-six 200-mm-diameter wafers per hour, or forty-five 150-mm wafers per hour, which is respectable but less than the output of most commercial-scale fabrication lines. IBM's synchrotron-based lithography facility, for example, is projected to be capable of exposing fifty to sixty 200-mm wafers per hour when it becomes fully operational next year.

Throughout the 1980s, IBM worked on X-ray lithography at the National Synchrotron Light Source at Brookhaven National Laboratory in Upton, N.Y. The work culminated in the fabrication of 64K-bit static RAMs and 1M-bit dynamic RAMs in a pilot plant at Brookhaven. Besides that facility, synchrotrons at the University of Wisconsin and at Stanford University in California have been used for research in lithography.

TWO CONFIGURATIONS. There are two basic configurations for lithography: proximity, in which the mask used to expose the circuit pattern is placed very close to the photoresist and the exposure is made in the manner of a contact print in photography; and projection, in which the mask is several times larger than the circuit it creates and its pattern is projected onto the photoresist from some distance away. U.S. and Japanese re-

Defining terms

Imaging system: in lithography, components or devices used to reflect, collimate, and otherwise manipulate X-rays, in the same way lenses and mirrors are used to manipulate light.

Lithography: the use of electromagnetic radiation to expose the pattern of an integrated circuit onto a wafer of semiconductor material.

Photoresist: the chemical compound sensitive to electromagnetic radiation that is used to coat a semiconductor wafer, so that the pattern of an integrated circuit can be exposed on the wafer during lithography.

Synchrotron: a device in which magnetic fields are used to accelerate subatomic particles, such as electrons and positrons, at speeds approaching that of light. The accelerating particles emit electromagnetic radiation, such as X-rays, when the magnetic field lines are perpendicular to the direction of the particles.

Glenn Zorpette Senior Associate Editor

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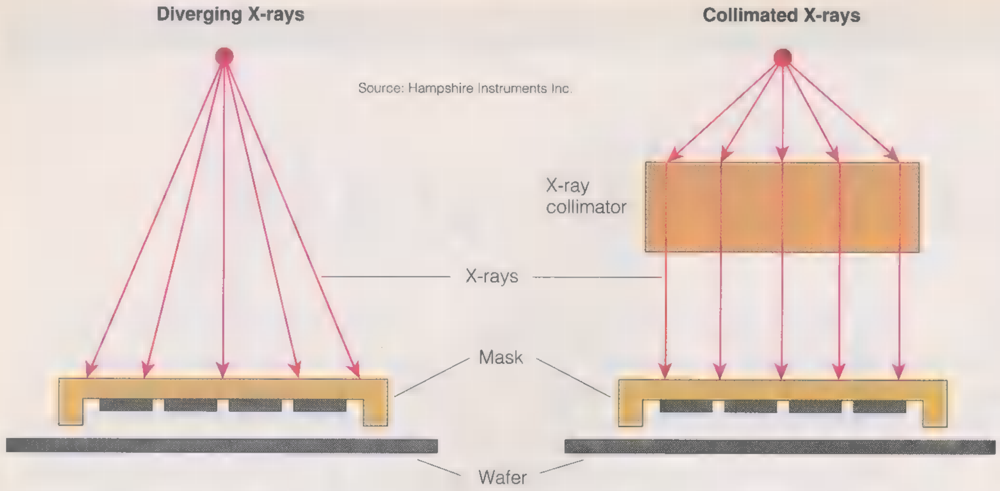


X-ray lithography is now done in a proximity configuration, in the manner of a stencil or a contact print in photography. However, when a point source is used, X-rays strike the edges of a mask at more acute angles than the rays hitting the center. The resulting discrepancy can cause defects that render the finished circuit defective.

searchers are now trying to develop both proximity and projection lithographic systems around low-cost point X-ray sources.

Most of these point sources create X-rays by aiming the beam of a laser, typically a neodymium laser, at a target made of gold, tin, iron, or some other metallic element with a high atomic number. A small plasma is created where the beam hits the metal, and the plasma emits X-rays in all directions. Both Sandia and Lawrence Livermore are working on improvements to this type of source, and several other organizations are working on so-called plasma-pinch sources, which produce X-rays by containing a plasma in a rapidly changing magnetic field.

In proximity lithography, one of the most intense areas of development involves work on devices to concentrate and collimate the radiation from the omnidirectional point-sources, making it possible to use them to resolve finer line widths. (To avoid confusion with visible-light lenses and mirrors, the word optics is often eschewed where devices for manipulating X-rays are concerned; these devices are sometimes called imaging systems.) At present, interest is high in the use of imaging systems to improve the performance of low-cost, point-source proximity systems.

BASIC TRADEOFF. The fact that these point sources emit X-rays in all directions sets up a fundamental tradeoff that limits performance, according to Lawrence Livermore's Barbee. On the one hand, the wafer cannot be too far from the X-ray source because the sources are not intense enough for an adequate exposure at a distance. On the other hand, the mask and wafer being exposed cannot be too close to the X-ray source because the X-rays striking the edge of the wafer will be traveling at more acute angles than the ones hitting the center of the wafer, and this divergence causes shadowing, blurring, and other edge effects that can limit the resolution of features that can be printed on the chip, as well as chip yield [see diagram above]. Minor irregularities in the gap between the mask and the wafer can also cause imperfections in the shadow pattern, rendering the chip defective.

In an attempt to solve these problems, researchers are investigating various devices to concentrate and collimate X-rays. According to James M. Forsyth, vice president for technology at Hampshire Instruments, the main benefit of using collimated X-rays, which travel in parallel, would be the ability to align finer line widths and thus increase feature density.

In the lithography of an advanced IC, up to 20 different separate exposures are sometimes made on top of one another in a process called overlay. During each exposure, different types of doping are achieved with different layers of photoresist and appropriate processing. In some parts of the circuit, the alignment of elements on different levels must be extremely precise—on the order of 30 percent of the smallest feature size, Forsyth noted. Hampshire's current-generation lithography system can align features as small as 0.35 μm, but by collimating the X-rays, alignment of 0.25-μm features might be possible, he said.

"There are advantages and drawbacks to each of the [imaging system] configurations, and really, none of them have proven themselves in a lithographic environment," Forsyth cautioned. Nonetheless, he said, "we anticipate that future generations of machines will benefit" by including devices to collimate X-rays, perhaps as soon as "a little over a year" from now.

LENSES AND MIRRORS. Two basic types of devices are currently under development for collimating X-rays. One is the Kumakhov lens, originally developed by Muradin A. Kumakhov and others at Moscow's Institute for Roentgen Optical Systems [see photo, p. 36]. Besides lithography, applications for the lens are being pursued in medicine, materials science, and X-ray astronomy ["Soviet X-ray 'lens' seen as promising," THE INSTITUTE, May/June 1992, p. 1].

In this system, tens or hundreds of thousands of tiny glass capillaries admit X-rays coming from diffent directions and guide them so that they emerge traveling in parallel. To be transmitted within the capillary, an X-ray must enter it at a very small angle with its central axis—no more than a fraction of a degree off. The X-ray then zig-zags through the tube, reflecting off its inner surface at very shallow angles. For good reflectivity, the tubes must be very narrow and the inner surface must be extremely smooth. According to experts in the technology, the Russians have found a way to use boron and other materials in the silicate glass to achieve the necessary smoothness.

Development of the Kumakhov lens for lithography is now being done collaboratively by Moscow's Institute for Roentgen Optical Systems, the Center for X-ray Optics at the State University of New York at Albany, and X-ray Optical Systems Inc., an Albany company formed recently to commercialize the lens. (In April, X-ray Optical Systems and the university were awarded a $1.9 million, three-year grant to develop the lens; the award was made by the U.S. Department of Commerce under its Advanced Technology Program.)

Last autumn, in experiments at the Roentgen Institute, wafers coated with photoresist were exposed to X-radiation collimated by a Kumakhov lens, according to Walter M. Gibson, professor of physics at the State University of New York in Albany. Although ICs were not fabricated, the experiment showed that the lens, used in conjunction with a plasma-pinch source, could provide X-radiation intense enough for lithography, Gibson said.

The other type of imaging system being considered for use in lithography is based on multilayer mirrors of the sort pioneered by Lawrence Livermore and other national laboratories. Although conventional mirrors would be useless in diverting X-rays, special mirrors, originally developed for X-ray astronomy, have been based on interfaces between two materials—one with a large number of electrons (typically molybdenum) and the other with relatively few electrons (typically silicon).

At each interface, only a tiny fraction of the incident X-rays are reflected, but up to 40 of the interfaces are layered in such a way that the reflected waves of X-radiation reinforce one another. The result is that reflections of up to 63 percent of the incident radi-

ation have been achieved. In order to collimate radiation from a point source, the mirrors are shaped like a paraboloid, with the point source placed at the focus.

WEIGHING THE ADVANTAGES. Each of these two imaging systems has its pluses and minuses. The advantages of the Kumakhov lens are its good radiation-gathering characteristics and potentially good collimation characteristics; its drawbacks are the potential size of a device with good collimation characteristics, and the need to smooth out the uneven radiation pattern that emerges from it (the X-rays are conducted through the hollow center of the tiny glass tubes and not by the walls of the tubes, so there are bright and dark regions in the pattern).

The advantage of the multilayer mirror is that it is compact and can be fabricated with existing technology, according to Richard R. Freeman, head of the advanced lithography research department at AT&T Bell Laboratories in Holmdel, N.J. However, with current assemblies, the proportion of reflected radiation does not appear high enough for lithography, Freeman said, citing a recent Lawrence Livermore–Bell Labs study that concluded that a paraboloid multilayer mirror was inadequate for X-ray lithography.

One optical expert, who asked not to be identified, is "not real optimistic" about the chances of the Kumakhov lens succeeding, either. However, several others contacted by *IEEE Spectrum*, including Hampshire's Forsyth and Livermore's Barbee, remain hopeful that the problems with both the multilayer mirrors and the Kumakhov lens will be solved and one or both will become critical elements of a commercial point-source X-ray lithography system.

> The new X-ray lithography may become an important adjunct to the synchrotron

Even if the multilayer mirror does not live up to these expectations, however, some researchers are counting on it to be the cornerstone of X-ray projection lithography. Researchers at AT&T and Lawrence Livermore National Laboratory are working independently on advanced mirrors that they hope will some day permit X-ray projection lithography. At the same time, a sizeable group of researchers from AT&T and Sandia's Livermore, Calif., laboratory are working together to develop a complete prototype X-ray projection lithography system (see diagram below).

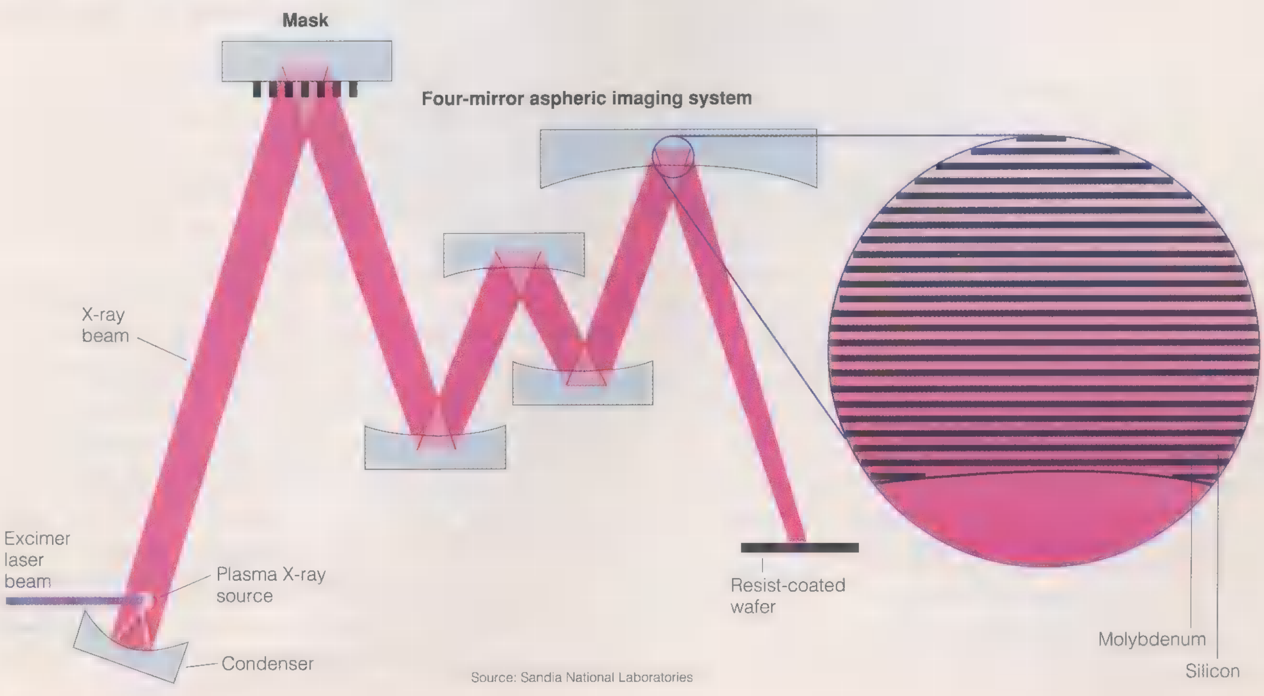
Early in 1991 AT&T and Sandia were the first to demonstrate X-ray projection lithography with a laser-plasma point source. "It's pretty well agreed that the best source for these systems is likely to be a laser-produced plasma," said Freeman, who had just returned from a Monterey, Calif., conference of researchers in X-ray projection lithography.

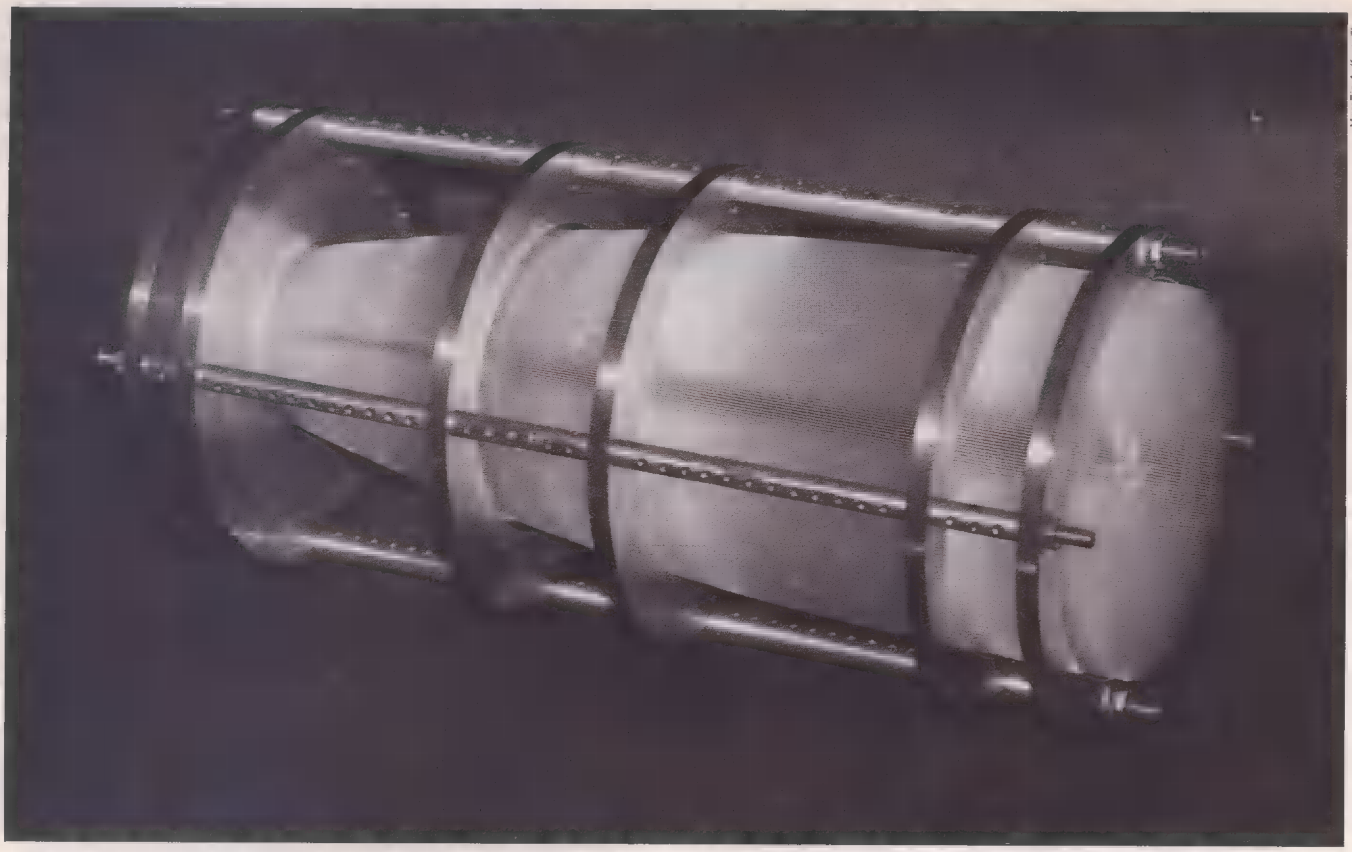
Today ultraviolet lithography is done in a projection configuration, and lenses are used to shrink the mask's image on the photoresist. But X-rays are absorbed in glass, so until now X-ray IC fabrication has always been done with proximity lithography. The problem is that the tiny features on the masks needed for proximity lithography are difficult to produce and leave little margin for error; with projection lithography, the masks (and features) can be made at least several times larger.

As currently envisioned, X-ray projection would require reflection masks, which the radiation bounces off rather than travels through. This type of mask presents its own set of difficulties, but they are ones that developers seem confident they can solve.

But those may be the least of their worries. Freeman emphasized that "a whole lot of technologies have to be worked out" before X-ray projection lithography becomes

Researchers at Sandia National Laboratories, Livermore, Calif., and AT&T Bell Laboratories, Holmdel, N.J., are developing an X-ray projection lithography system based on multilayer mirrors. In these mirrors, interfaces between two materials, such as molybdenum and silicon, each reflect a small fraction of the incident X-rays, but in such a way that the reflected waves of X-radiation reinforce one another. During an exposure, the X-ray beams are stationary, but the mask and wafer must move to transmit the pattern through the imaging system. The mask moves from left to right, enabling the X-ray beam to scan across it. Simultaneously, the wafer moves from right to left, as the mask's pattern is exposed on it.





Muradin A. Kumakhov

The first prototype capillary lens for lithography was fabricated at the I.V. Kurchatov Institute of Atomic Energy in Moscow in 1988. X-rays in a 28-degree cone of radiation enter the lens at left and emerge from the wider opening at right with a difference of no more than about a tenth of a degree between any two beams. The lens, which was built by Muradin A. Kumakhov and others, is just over a half meter long and conducts X-rays within 12 000 hollow glass fibers with inside diameters of 0.36 mm.

a commercial reality. For example, the mirrors for a projection system would have to be aspherical in shape: similar to spheres, but more curved in at the edges. They would also have to be accurate to within 1 nanometer, which "exceeds the capabilities of the optical industry in the world at the moment," he said. Even the optical techniques to measure this kind of accuracy are not yet available.

Nonetheless, the promise of such a system for IC fabrication is likely to keep researchers busy trying to overcome the technical obstacles. For example, a point-source X-ray projection system will have the advantage of being compatible with existing wafer fabrication facilities, whereas entirely new facilities will have to be built around synchrotron-based fab lines.

Also, the wavelengths needed for projection lithography are around 13 nm—or about 10 times the length of those needed for proximity lithography—and laser-plasma sources that emit these longer wavelengths are already commercially available.

HEDGING BETS. It is possible that synchrotron-based facilities will initially outperform point-source systems in high-volume manufacturing applications. Some experts believe X-ray IC fabrication may diverge into two categories: synchrotron-based fab lines for dynamic RAMs and other high-volume products, and point-sources for application-specific ICs, some types of microprocessors, and other chips produced in smaller quantities.

Further details, however, remain sketchy. Few if any researchers say they can confidently predict the future of the technology and several companies, including IBM, are hedging their bets. "We have closely followed, and will continue to follow, developmental efforts in advancing the technology associated with the Kumakhov lens," said Juan Maldonado of IBM's X-ray program office in East Fishkill, N.Y. "While the lens could make available granular X-ray sources for X-ray lithography systems, more development efforts are required. In the meantime, IBM will continue to pursue synchrotron-based X-ray lithography technology and evaluation," Maldonado told *Spectrum*.

AT&T and Motorola are also pursuing dual approaches. While it works on point-source projection lithography with Sandia, AT&T is also working on synchrotron projection lithography with Brookhaven National Laboratory. And while Motorola is evaluating Hampshire Instruments' point-source lithographic system, it is also laying the groundwork for a $30 million synchrotron project to begin next year.

"There will probably be a role for both synchrotron and point-source lithographic systems," said Hampshire's Forsyth. "It becomes a volume-economy issue that probably won't resolve itself for some time."

TO PROBE FURTHER. The *AT&T Technical Journal* published an article titled "Developing a Soft X-ray Projection Lithography Tool" in its November/December 1991 issue, which can be obtained through the AT&T Customer Information Center, Box 19901, Indianapolis, Ind., 46219; or call 800-432-6600.

An issue of *Physics Reports*, published by North-Holland, was devoted to "Multiple Reflection from Surface X-ray Optics." The issue, by Muradin A. Kumakhov and F. F. Komarov, was Vol. 191, No. 5 (August 1990). North-Holland is part of Elsevier Science Publishers, Box 1991, 1000 BZ Amsterdam, the Netherlands.

The Physics of Submicron Lithography is a new textbook by Kamil A. Valiev of the former Soviet Union's Academy of Sciences in Moscow. One of the book's six chapters is devoted entirely to X-ray lithography, including material on synchrotron sources, optical components, and multilayer reflectors. The English-language version of the book is available from Plenum Press in New York City and London.

New Scientist, the British weekly, published a general article on lithography in its April 18 issue. Although the article discounts nonsynchrotron-based X-ray sources, it is a useful summary of the state of other lithographic technologies. ◆

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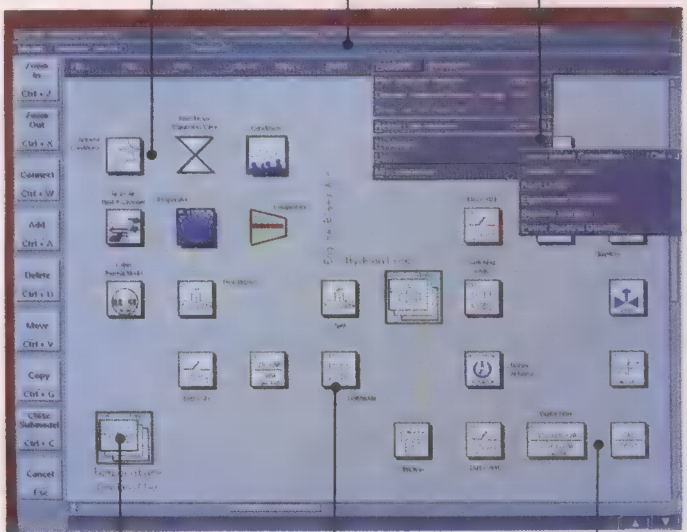

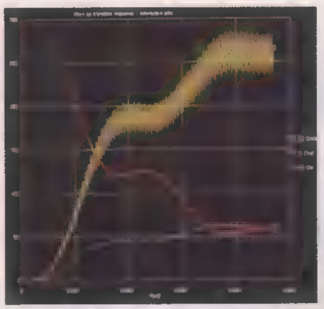

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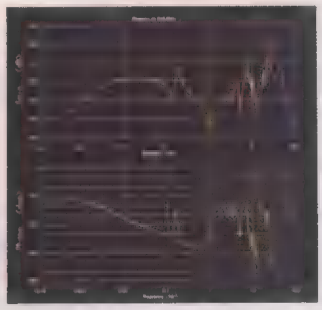

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CASE's missing elements

Key functions must be added to computer-aided software engineering tools, and thorough training is needed in their use

Software engineering has become one of engineering's largest occupational fields. At the beginning of this year, the U.S. population of software engineers and professional programmers totaled about 1.7 million and, although the global total exceeds 10 million, software engineers are still in short supply in many industrialized nations, such as Japan.

Multitudes of software engineers are needed because software systems now require the highest skilled manual content of any form of engineered product. Since skilled manual labor is expensive, in short supply, and not altogether predictable in terms of results, it is obviously desirable to automate the process of software development as much as possible.

The automation effort is known as computer-aided software engineering (CASE) in the United States and Far East, as integrated programming support environment (IPSE) in Europe. CASE encompasses the collective attempts by many vendors to provide tools that reduce the manual work of software projects. Integrated CASE (I-CASE) implies a higher level of inter-tool cooperation.

Besides minimizing the labor content of software, CASE also looks to enhance its quality and reliability. All CASE vendors and clients agree with these two goals, but exactly how to achieve them is still in the trial-and-error phase. Currently, CASE/IPSE and I-CASE technologies look promising but are still immature.

Benefiting from these technologies will require preparation and training. For example, CASE tools are designed to support a methodology—an approach to software engineering such as structured programming, for example—the user may prefer. The tools are not a methodology in and of themselves nor can they impose one.

Thus, an organization must examine CASE tools in the light of the methodologies it has already adopted or wishes to use. A company should also be certain that the methodology is fully inculcated and the uses for the tools fully understood before attempting a project.

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CASE'S SIX CHALLENGES. The phases of software development, as for other engineered products, entail six generic activities:

- Client or user requirements are explored and defined.
- A computer program or software system is designed to meet the requirement.
- The program or system is constructed (using one or more of several hundred available programming languages).
- User training and reference materials are written.
- The program or system is thoroughly tested to ensure that it meets requirements.
- After deployment, the software package is enhanced or repaired as needed.

It might seem that automating these activities is straightforward, but a deeper analysis reveals six chronic problems of software engineering that make CASE especially challenging.

The first problem is that client or user requirements for software tend to be extremely volatile. After the requirements definition phase, the observed rate of growth in user requirements averages about 1 percent per month throughout the remainder of development. Thus for a three-year software project, about one-third of the functionality delivered will have been added to the originally defined requirements.

> Software systems require the most skilled 'piecework' effort of any electronic product

This rate of change for software appears high compared to other forms of engineering. Indeed, new and changed user requirements for software seem perpetual. On the average, the rate of new and changed functionality in deployed software is between 5 and 7 percent per year for as long as the software is operational and in use.

The challenge for CASE tools is to support frequent modifications to all the plans, specifications, code, and other deliverables for software projects. Further, they must control and synchronize the resultant updates to deliverables, a process termed configuration control. Here, CASE and software engineering have been fairly successful.

A second problem is that software systems, because they tend to be extremely complex, are highly error-prone. Historical data indicates that 25–50 percent of the total costs of software development are associated with various forms of defect removal and quality control.

CASE tools should therefore support both standard and advanced forms of defect prevention and removal, as well as defect tracking and analysis. Standard forms of defect removal include reviews, inspections, testing, and defect tracking; advanced forms include

Defining terms

Computer-aided software engineering (CASE): tool suites that attempt to automate some of the manual activities associated with software engineering. (Some authors tend to use CASE for single-user tool suites and integrated programming support environment for multi-user tool suites, but such usage is nonstandard.)

Integrated computer-aided software engineering (I-CASE): tool suites that attempt to support a broad range of software engineering activities; they normally include support for early-phase activities such as design, mid-phase activities like coding, and late-phase activities like testing.

Integrated programming support environment (IPSE): tool suites for automating software engineering activities. (Similar to CASE and I-CASE, the term is more widely used in Europe than CASE; some authors tend to use IPSE for multi-user tool suites and CASE for single-user tool suites, but such usage is nonstandard.)

Lower, middle, and upper CASE: tools that support, respectively, mid- to late-phase activities, such as coding and testing; mid-phase activities such as configuration control; and early phase activities, such as requirements and design. There is no precise boundary for deeming a tool or function lower, middle, or upper CASE.

Quality function deployment (QFD): a formal technique for identifying quality attributes important to users and ensuring that a product explicitly meets each quality goal.

Total quality management (TQM): A set of practices (and a philosophy) for improving the process of development and maintenance and for evaluating the effectiveness of process improvement on the products themselves.

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quality function deployment (QFD) and total quality management (TQM).

In meeting this challenge, the CASE industry has moved slowly, with only a few vendors offering explicit quality control features as part of their CASE tool suites. Failure to provide adequate support for the most expensive activities in all of software is a major deficiency of the CASE industry.

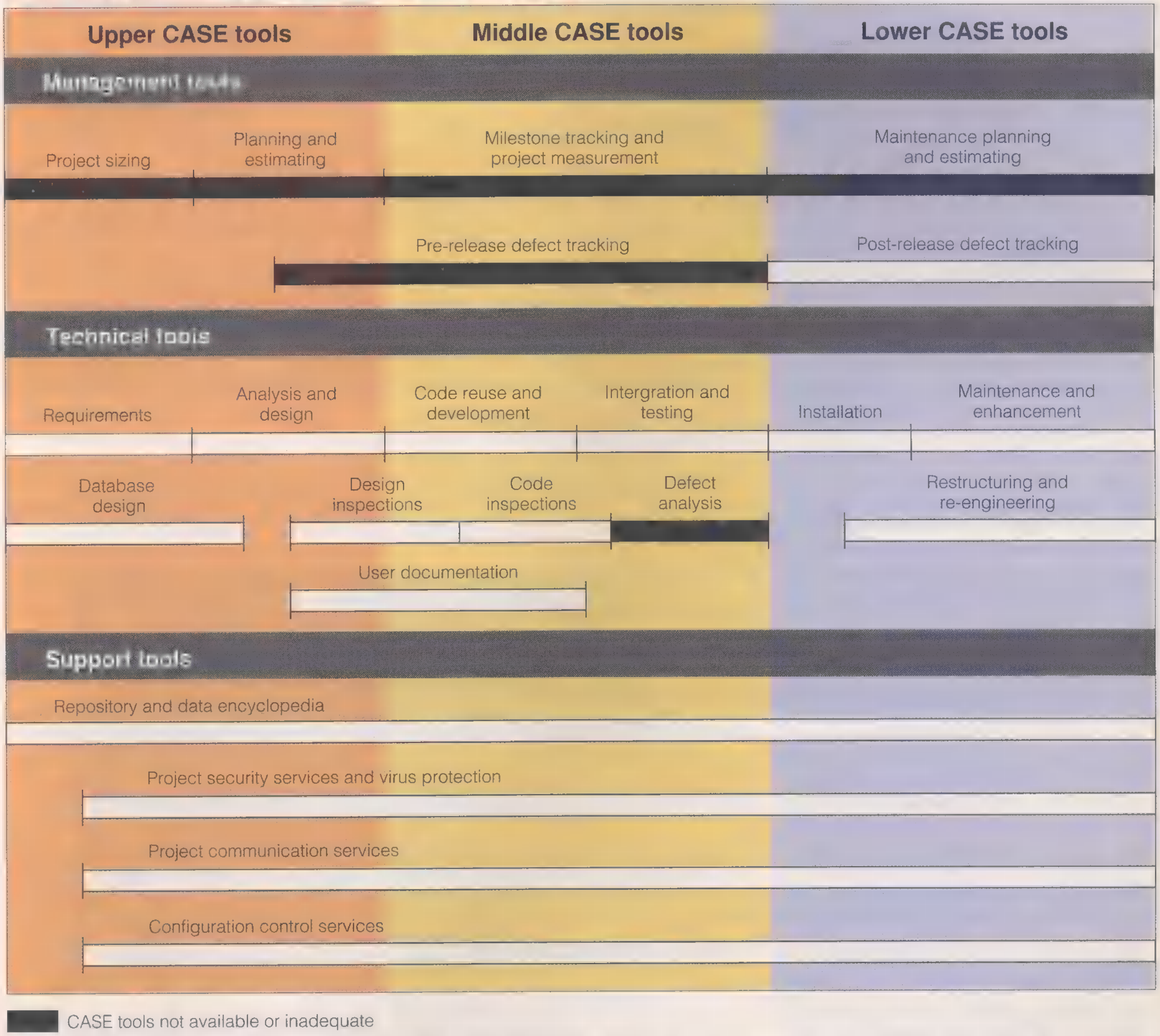
Third, software projects tend to generate an enormous quantity and diversity of paperwork. Large military software systems, for example, create a total of about 400 English words for every statement in the Ada programming language and produce large piles of diagrams and tabular material. Indeed, more than 50 percent of the entire cost of U.S. military software is devoted to paperwork, while pure coding accounts for less than 20 percent. Counting planning, specification, and training documents, as well as various user manuals, a total of more than 50 discrete kinds of documentation will be produced for a large software system.

To date, the CASE industry has not fully succeeded in dealing with the paperwork challenge. Most forms of planning document are not fully supported, and only a few vendors provide full support for military specifications such as DOD-STD-2167A (which requires the creation of more than 50 different document types). Also, the concept of templates for standard document types is missing from CASE tool suites.

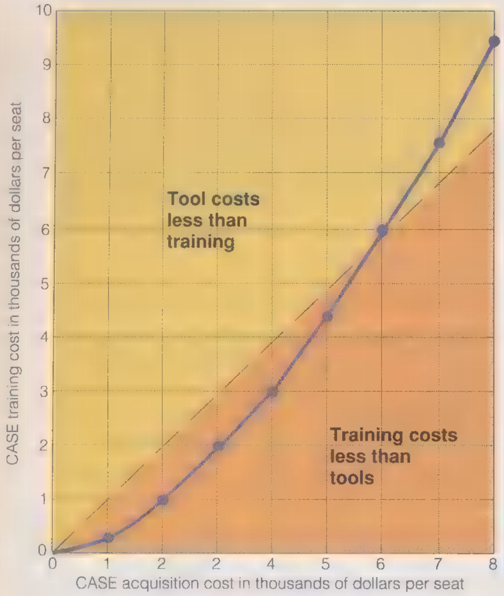
The fourth problem is that, since software is highly labor-intensive (engineering and support staffs for large software projects may number in the hundreds), the communication and coordination functions span a rather broad bandwidth. Obviously, single-user tools are not sufficient for large team projects. Plans, status reports, specifications, modifications and changes, source code, and test cases must be available as needed across heterogeneous, distributed organizations. CASE vendors are just stepping up to this challenge, and full network support for large teams is now available.

Fifth, each component of a software system must now be built from scratch. The lack of reusable components has been a weak link in the chain of software engineering technology since the software industry began 50 years ago. The challenge for software tools is to support reusability at multiple levels: project plans, specifications, code, and documentation.

CASE tool functions and the software life cycle



[1] A basic computer-aided software engineering (CASE) tool schema has both horizontal and vertical relationships. The horizontal, temporal division uses the terms upper, middle, and lower as roughly equivalent to R&D, manufacturing, and field service. Vertically, the division of tools by function—management, technical, and project support—more clearly expresses tool relationships.



[2] The cost of training software engineers to use computer-aided software engineering tools tends to rise more rapidly as the cost of the tool increases. This is because the more expensive tools have greater functionality so that the would-be user needs more training to fully utilize the tool.

Here the CASE vendors are starting to recognize both the market and technical potential of reuse. To date, though, support for reusability has been marginal. But the prognosis for the near future looks excellent. The coupling of CASE technologies with the object-oriented paradigm is starting to lead to a significant expansion in reusability at all levels. Whereas ordinary procedural languages such as Fortran rarely produce more than 15 percent reusable code, with object-oriented languages such as Smalltalk and Objective-C, reusable code often exceeds 50 percent, owing to the concept of inheritance embedded in the language. Although object-oriented analysis and design techniques are not as advanced as the languages, they are advancing rapidly.

The sixth problem is that software does not age gracefully. The steady accumulation of an additional 5–7 percent new functionality each year, coupled with frequent defect repairs, tends to degrade the structure and increase the entropy of software systems over time. Even without considering inflation, the costs of modifying software systems tend to increase by 2–4 percent each year as the structure slowly degrades.

To combat this problem, CASE vendors began to provide a set of mutually supportive geriatric technologies in 1985. The set includes automatic restructuring, reverse engineering, and re-engineering. As yet, these geriatric technologies are not universally available in CASE tool suites, and are limited to the more widely used software languages such as Cobol and C.

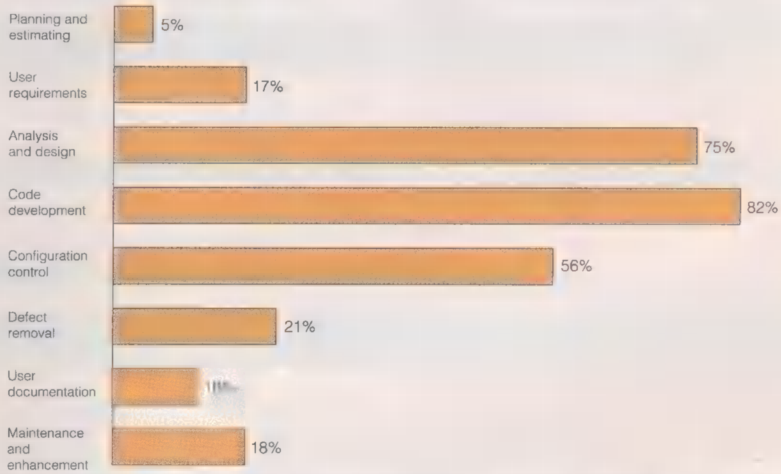
How CASE tools are structured can be viewed from several perspectives, one of which is the clients served by CASE tool vendors. The CASE market comprises vendors that support information systems, those that support systems software, and others that support military software. There is relatively little overlap between the information-system CASE companies and those in the other two markets. Several vendors support systems and military software equally.

The functions CASE tools support are often labeled after the horizontal development stage in which they occur [Fig. 1]. A function ocurring in the early phase, such as requirements or design, is termed upper CASE. Lower CASE is applied to later activities such as coding, testing, and integration, and middle CASE to such central activities as configuration control. However, this terminology is often ambiguous.

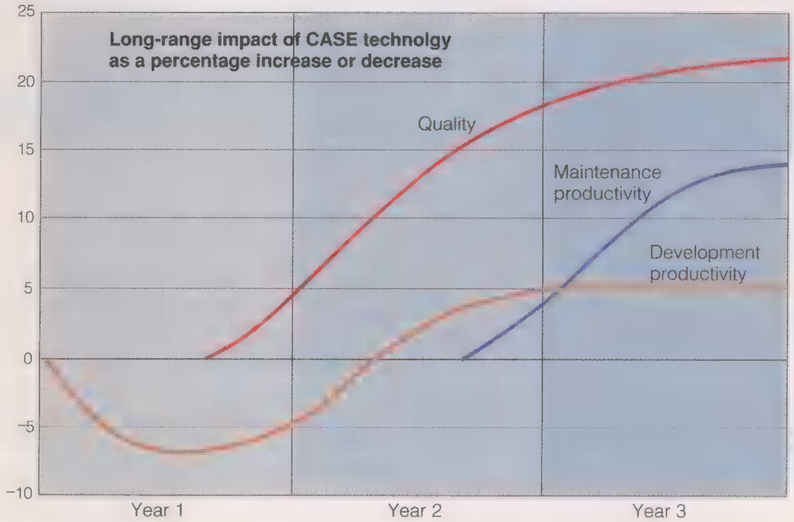
Another way of viewing CASE functions is vertically, with management, technical, and support functions on the top, in the middle, and underneath, respectively. This vantage yields a clearer picture.

Using this approach, ITT Corp., New York City, carried out a study of the complete set of integrated CASE functions needed by a large, multinational corporation in the early 1980s, identifying over 100 discrete functions. More recently, the AD/Cycle and Cohesion architectures for CASE tool hierarchies, from IBM Corp. and Digital Equipment Corp., Maynard, Mass., respectively, have vertically mapped out the set of functions that should be in CASE tool suites, and have specified how they can interconnect and share data by means of a central repository.

The key set of management functions that should be in CASE tool suites include project sizing; planning, cost estimating, and quality estimating; tracking and measurement; and risk and value analysis. Today, only a few CASE vendors provide any



[3] When clients of Software Productivity Research Inc., Burlington, Mass., were asked for what technical activities CASE tool suites were being used last year, their answers underscored the strengths and weaknesses of current CASE offerings.



[4] When data from formal studies, such as those performed at Hewlett-Packard Co., Palo Alto, Calif., is combined with that from informal discussions with CASE clients, quality improvement, rather than productivity, is seen as the major perceived benefit of using CASE tools—despite the fact that defect-control tools are missing.

management support as part of their CASE tool suites.

As for technical functions, the key set that CASE should support includes initial requirements; analysis and system design; data modeling, database design, and construction; design inspection and complexity analysis; reusable designs, code creation, and reusable code support; and code inspection and configuration control.

Also included are integration, pre-test defect removal, test case creation and control, and test support; defect tracking and analysis; user documentation support and screen design; restructuring, reverse engineering, and re-engineering; and maintenance and enhancement. Most CASE vendors support some of these functions. Commercial CASE tools range from those supporting only one or two to those supporting over half.

In spite of widespread claims by CASE vendors that they offer "full life cycle support," no vendor in 1992 supports all functions. The most visible gaps—for both civilian and military projects—are in project management (support for formal reviews and inspections as well as QFD); pre-test defect removal, test case creation, and support; and defect tracking, analysis, and documentation support.

For support, or substrate, functions the key set that CASE vendors should offer includes a data encyclopedia and repository, security and virus protection, communication, and configuration control. Most of these support functions are now covered reasonably well by CASE vendors, except for virus protection, which is missing from essentially all CASE tools, but can (and should) be acquired separately.

Because CASE tool suites are not complete, interested organizations should try to acquire tools with an open architecture, even though vendors may wish to provide closed-architecture suites. Helpful in obtaining such tools is the Trial-Use Standard For Computing System Tool Interconnections released last year, IEEE Std 1175-1991.

EXTENSIVE TRAINING NEEDED. At the Santa Clara, Calif., CASEWorld conference in February, Chuck House, a former executive of Hewlett-Packard Co., Palo Alto, Calif., presented the results of a three-year study on how CASE was utilized within the HP laboratories. Differences among similar tools had little effect on the results.

The most notable factor that separated successful from unsuccessful CASE usage was the adequacy of the training received in the capabilities of a particular vendor's CASE tool. Without a significant investment in training, the study showed that the failure rate of CASE deployment tends to exceed 50 percent.(In this context, the word "successful" meant that the tool continued to be used after the study was finished, the users were relatively happy with it, and some tangible benefits were noted. "Unsuccessful" meant that the tool was abandoned early, the users were dissatisfied, or the tangible results were zero or negative.)

House's observations have been replicated by other organizations, including Software Productivity Research Inc., Burlington, Mass. The research shows that successful CASE usage may require between US $0.50 and $2.00 in training expenses for every $1.00 spent on the CASE tools themselves. Software Productivity Research has observed that the more expensive tools normally require more extensive, costly training [Fig. 2].

USAGE PATTERNS. Since CASE tool suites are both new and in rapid evolution, no archetypical pattern for their use exists. But interviews and consulting studies with CASE users performed by Software Productivity Research indicate that the normal sequence of acquisition and deployment of CASE tools—whether for information systems, systems software, or military software—follows a similar pattern.

Defect removal and quality control are expensive and a challenge for all software writers

Initially, a single copy of a CASE tool suite is installed and used on a pilot study in an exploratory manner. If the pilot study, normally run from one to a maximum of six months, is reasonably successful, additional copies will be acquired over a period that may run to a year or more.

CASE usually supplements conventional software development methods, rather than ousting them. This is due both to the gaps in CASE support and the normal sociology of deploying new technology. The usage pattern of CASE tools shows a heavy concentration in three technical areas: analysis and design, code development, and configuration control [Fig. 3].

CASE ECONOMICS. Because the CASE industry is barely more than 10 years old, there are no long-range studies on the economics of CASE. Over half of all CASE users have under three years of experience with it.

Surprisingly for an industry whose marketing cry is improved productivity, the CASE vendors have published no controlled studies that validates their claims. Current data [Fig. 4] indicates that for the first year of CASE usage, software development productivity tends to fall *below* the prior average values. This is normal for new technologies that need extensive training and have a lengthy learning curve.

However, when projects developed with CASE tool suites enter production, maintenance is often easier than for non-CASE projects because of the configuration control and update support provided by the CASE tool suites. Also, CASE tools that support complexity analysis, restructuring, reverse engineering, and re-engineering tend to facilitate maintenance tasks.

What is astonishing about the data is that in spite of the lack of explicit support for defect removal, defect reporting, and defect analysis in CASE tool suites, the quality impact from CASE usage is perceived as one of the more important benefits. This anomaly occurs because materials produced with CASE tools appear to be easier to review and test, though the actual reviews and tests take place outside the CASE environment.

The payback period for CASE tools varies with the functionality provided by the tool, the cost per seat, the training provided to the technical staff, and the usage patterns. Under optimal conditions, as when the acquisition of CASE tools and associated training coincide with the start-up of several important software projects, the economic payback period can be less than two years.

More usually, as when CASE tools are used experimentally on minor projects, the payback period will exceed three years. Under worst-case conditions, projects that are never completed, there may not be a payback period.

TO PROBE FURTHER. An overview of CASE is provided by Carma McClure in *CASE is Software Automation* (Prentice Hall, Englewood Cliffs, N.J.,1989). For additional quantitative data on the software life cycle, see Capers Jones's *Applied Software Measurement* (McGraw-Hill, New York City, 1991).

Both the IEEE and the International Organization for Standardization/International Electrotechnical Commision (ISO/IEC), both in Geneva, Switzerland, are developing standards for tool database elements, data interchange formats, and the evaluation and selection of CASE tools. For more information about IEEE standards efforts, contact John Horch, 705 Larry Dr., Suite D, Madison, Ala. 35758; 205-464-9530. For information about ISO/IEC programs, contact Peter Voldner, 483 Bay St., Floor 12, Toronto, M5G 2E1, Canada; 416-581-5619.

Washington University in St. Louis, Mo., hosts a well-known annual CASE conference. Among the commercial CASE conference sponsors are Digital Consulting Inc. of Andover, Mass., Technology Transfer Institute of Santa Monica, Calif., and Extended Intelligence Inc. of Chicago.

A fairly complete listing of CASE tools marketed in the United States, as well as to other kinds of software tools, is "The Guide to Software Productivity Aids," published four times a year by Applied Computer Research Inc. of Phoenix, Ariz.

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Grounds for signal referencing

As more sensitive electronic systems face an increasingly hostile electromagnetic environment, grounding demands more care

In many industrial and commercial facilities, electrical grounding systems have become an unreliable signal reference because of noise pollution induced by high inductive reactance and electromagnetic interference (EMI). Matters have only worsened with the installation of local-area networks that rely on inexpensive cabling to transmit high-speed data.

To be sure, the primary source of proper safety grounding practice is the the National Fire Protection Association's 1990 National Electrical Code (NEC). But it would take volumes to fully address the vast, complex issues involved in signal-reference grounding, a keener awareness of which may stem the spread of problems with signal-reference grounds.

NOISE ANNOYS. As the use of stand-alone personal computers, mainframe computer facilities, computerized test facilities, manufacturing electronic process controls, communications and other electronic equipment proliferated in the 1980s, electric utilities, customers started complaining of problems with electronic equipment. Then, in 1990, problems increased as networking of computer hardware became widely affordable and smaller companies with personal computers were drawn to this economical means of sharing peripherals and productivity-increasing software. Many were unaware (as are a lot of equipment vendors and utilities) of the range of problems that can be associated with certain types of data communication cables.

For instance, unshielded cables are inexpensive and often used for local-area networks (LANs) intended to support multimegabit-per-second digital data transmission rates. But unshielded cables are especially vulnerable to noise when signal levels are reduced to increase transmission speed. One effect is system lockup or freezeup, where the user's equipment fails to communicate with other system components, because it cannot transfer data without errors.

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When problems such as this arise, the equipment vendor frequently suggests that the cause may be "dirty power" from the utility power line. And since effects such as lockup may in fact be power related, power companies have become knowledgeable about "the other side of the meter"—the customer's wiring, grounding and site-specific voltage disturbances—not to mention such causes as a lack of electromagnetic compatibility (EMC) between data communication cables and on-site electronic equipment. Many utilities are now using this knowledge to provide a higher level of customer support, regardless of which side of the meter the problem is on.

Achieving a technical understanding of these problems is not simple. Although multiple societies within the IEEE (for instance, Power Engineering, Industry Applications, Computer, Electromagnetic Compatibility, and Power Electronics), deal with specialized aspects of electronics, no single group ties everything together into standards that would ensure reliable installations amid an ever noisier electrical environment.

Nonetheless, the power industry's customer service representatives have noted common installation practices that militate against an electrically clean environment. Furthermore, they have found remedies that, while best applied during the system design and installation phase, may also be used on existing installations.

> No one group exists to write standards for grounding *and* electromagnetic compatibility

WHAT'S THE PROBLEM? Of most concern are communication ground loops, which can result in common-mode noise, and electromagnetic interference (EMI), whether conducted or radiated.

Consider two workstations on different floors of a large facility connected by a LAN. The data link provides a ground path between the units and each unit is also connected to main power ground, but through different feeders/branches of the power system [Fig.1]. Because the units tie into the power system at widely separated points (in an electrical impedance sense), a difference in ground potential usually arises and can cause a noise current to flow in the ground line and impair communications.

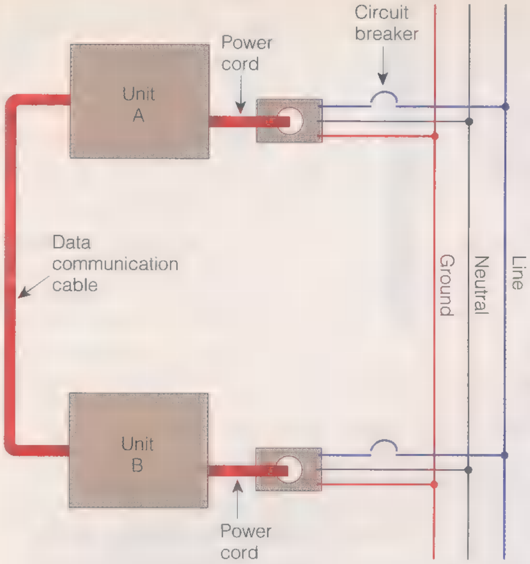
According to the Electric Power Research Institute (EPRI), Palo Alto, Calif., about 80 percent of EMI problems are due to conducted EMI generated within the facility; the remainder is generally attributed to the utility system. Radiated EMI is becoming a major problem due to increases in emissions within facilities, and the use of more susceptible—higher frequency, lower signal strength—equipment and systems. Magnetic coupling is an increasingly frequent cause of problems and can also be the most problematic to deal with when it upsets data transmission; it requires close attention to inductance of circuit loops. Capacitive coupling and radiated electrical emissions round out this general list.

While equipment susceptibility varies widely, as a rule of thumb radiated-field levels are problematic above 1 microtesla (at 60 Hz) for magnetic-field coupling and 1 V/m for electric-field coupling. Radiated magnetic fields above the 1-μT level can often be found around electrical panels, while electric fields above 1 V/m are frequently measured near desktop fluorescent lamps, especially those that employ high-frequency electronic ballasts.

Similarly, for conducted disturbances, the susceptibility levels of concern are about 100 V, peak impulse for normal and common mode, and 1 V neutral-to-ground rms voltages for common mode. Simple light switches can propagate a 100-V peak impulse, while commercial/industrial buildings are typically in excess of the 1-V rms level, which is especially aggravated by the use of metallic conduit as the only grounding conductor.

The origin of conducted and radiated problems may be traced to one or more of a baker's dozen of causes. For conducted interference, a major source is nonlinear electronic loads—especially rectifiers—and inverters and the main path is usually metallic conduit used for routing wires around the facility.

Properly designed and installed isolated-



[1] A communication path between two distant electronic systems can create a noise-generating ground loop if each piece of equipment is grounded to a different point on the power lines. The answer is to ensure that both systems are at the same ground potential.

grounding receptacles [Fig.2] should be used for grounding instead of metallic conduit. In most facilities today, metallic conduit is used exclusively as the universal ground for all electronics; it serves as a power-safety ground as well as the signal reference ground, and as the ground into which noise is dumped by such devices as surge protectors and filters commonly used with personal computers. This obviously aggravates signal-reference grounding problems due to conducted interference throughout the facility.

In some facilities, there may be hazards because equipment has been set up with an isolated ground that is not in accordance with electrical codes [Fig. 3]. To be properly grounded, the equipment housing must be electrically connected to the power-source ground. In general, a two-path grounding scheme—in which a ground wire is connected to the power-source ground and the power-line shielding is also connected back to the system ground—is used.

However, some equipment has insulated bushings at the power inlet of the equipment. The bushing prevents the shielding from making ground contact at the equipment cabinet and, if the equipment ground wire is not connected to the power-source ground, there is a safety hazard as well as a potential noise problem. Simply adding a ground at the cabinet does not alleviate the hazard, since the added ground and the system ground may be at different potentials.

High ground-loop inductive reactance and noise become problems when data-cable grounds are not terminated at the same ground potential. This is especially true at today's higher clock and data transmission rates when the frequency-inductance product is too high. It can also be a problem when an equipment-grounding wire, commonly called a green wire, is routed outside conduits with circuit-current-carrying conductors. (Note that this kind of routing is illegal, according to the NEC.)

Quite ordinary building and plant systems can be a source of radiated and conducted emissions. Among those found in almost any building today are heating, ventilation and air-conditioning systems; elevators; fluorescent lights; office machines, especially copy machines; electric tools and appliances, and dimmer controls with nonlinear converters that generate harmonics, electrical noise, and impulses. Factories add to this list with process controllers (with silicon controlled rectifiers, for instance), production machines, and arc welding machines.

In hospitals, clinics and medical offices, radiology, electrosurgical, and diathermy units are likely culprits, while in offices with broadcasting equipment, fm, am, TV, and radar transmitters are suspect. Finally, it may be possible to trace intermittent problems to the use of cellular telephones, police/emergency transceivers (walkie-talkies), or remote controls near sensitive equipment.

Of course, computers and all other equipment with nonlinear converters can also generate harmonics, electrical noise, and impulses. Interestingly, equipment used to correct line noise problems—filters or transient voltage surge suppressors—can corrupt the ground by dumping noisy current onto an otherwise clean signal-reference ground.

Any high current, including those due to a ground-fault or inrush currents from, say, electric motors, may create propagating magnetic fields. Such fields can upset nearby high-resolution monitors, high-density disk drives, and other magnetosensitive devices—possibly when an electrical panel is on the other side of a wall from a desk with a personal computer.

Often, noise can be injected by radiated coupling with the data cables that interconnect equipment, particularly if untwisted and/or unshielded pairs are the medium. One source of such noise is fluorescent lighting, whose magnetic ballast and electric arcing often generate high fields.

Connections or contacts that arc can also be troublesome. Arcing can occur not only if contacts are defective, but merely if vibration has shaken them loose. Often, the answer is regular inspection by a qualified electrician with a screwdriver.

Typical electric utility EMI sources are power-line corona, arcing, lightning strikes, or line switching devices. Utilities can usually tell customers when such events occur.

For a facility grounding system, the measured grounding electrode resistance should be below at least 25 Ω (NEC, Article 250-84), and below 10 Ω (MIL-HDBK-419A). The National Electrical Code is, of course, the ultimate source of detailed safety considerations, including fault protection and lightning protection. Some possible facility safety-code violations are noted here because of their impact on electronics grounding.

If neutral-to-ground bonds are not in accordance with NEC 250-21, 250-61, and similar articles, the grounding conductor becomes a load-current-carrying conductor. Not only is this condition unsafe, but such bonds aggravate signal-reference ground problems.

Grounding electrodes not in accordance with NEC 250-81 and grounding conductor routing that does not agree with NEC 250-57 also violate the "zero" signal-reference ground voltage design criterion for sensitive

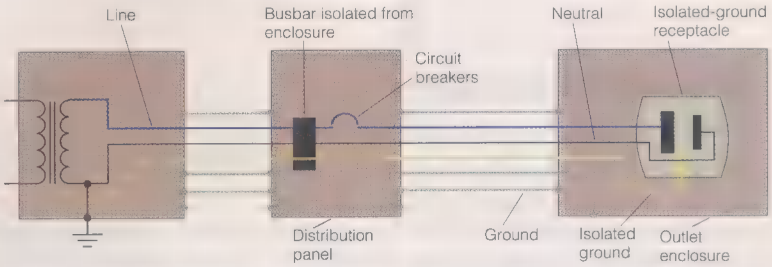
Defining terms

Balun: a passive device with distributed electrical constants used to couple a balanced to an unbalanced system, hence "balun".

Common-mode noise: the noise voltage that appears equally and in phase from each signal conductor (line and neutral) to ground.

Electromagnetic compatibility (EMC): the ability of electronic equipment or systems to work efficiently in their intended operational electromagnetic environment.

Electromagnetic interference (EMI): impairment of an electromagnetic signal by radiated or conducted electromagnetic disturbance.



[2] Using a separate, isolated ground (IG) as a signal reference ground avoids problems due to noisy power grounds. The IG "green" wire (shown in yellow) must be connected directly to the source ground (not the metallic conduit) and not have significant self-inductance.

electronic equipment and cabling.

Obviously, it is most desirable that the electronic system reference ground be "zero" volt at all operating frequencies and points. (It has been informally suggested that a difference in operating ground of less than 0.25 V between any two communicating devices can be considered zero; whether such a level is acceptable depends on the susceptibility of data communications devices.) It should also always be zero: thus no transient voltage or current disturbances may pollute it.

The nub of today's equipment problems, as Henry W. Ott points out in *Noise Reduction Techniques in Electronic Systems*, is that engineers all too often design their systems to operate under ideal, laboratory conditions, instead of real-world electromagnetic environments. Well-designed equipment should not be adversely affected by external noise sources, nor should it add appreciably to the environmental noise. Conversely, as system consumers, engineers should insist on provable EMC in systems they purchase.

About 80% of the time, conducted interference is generated within the very facility experiencing problems

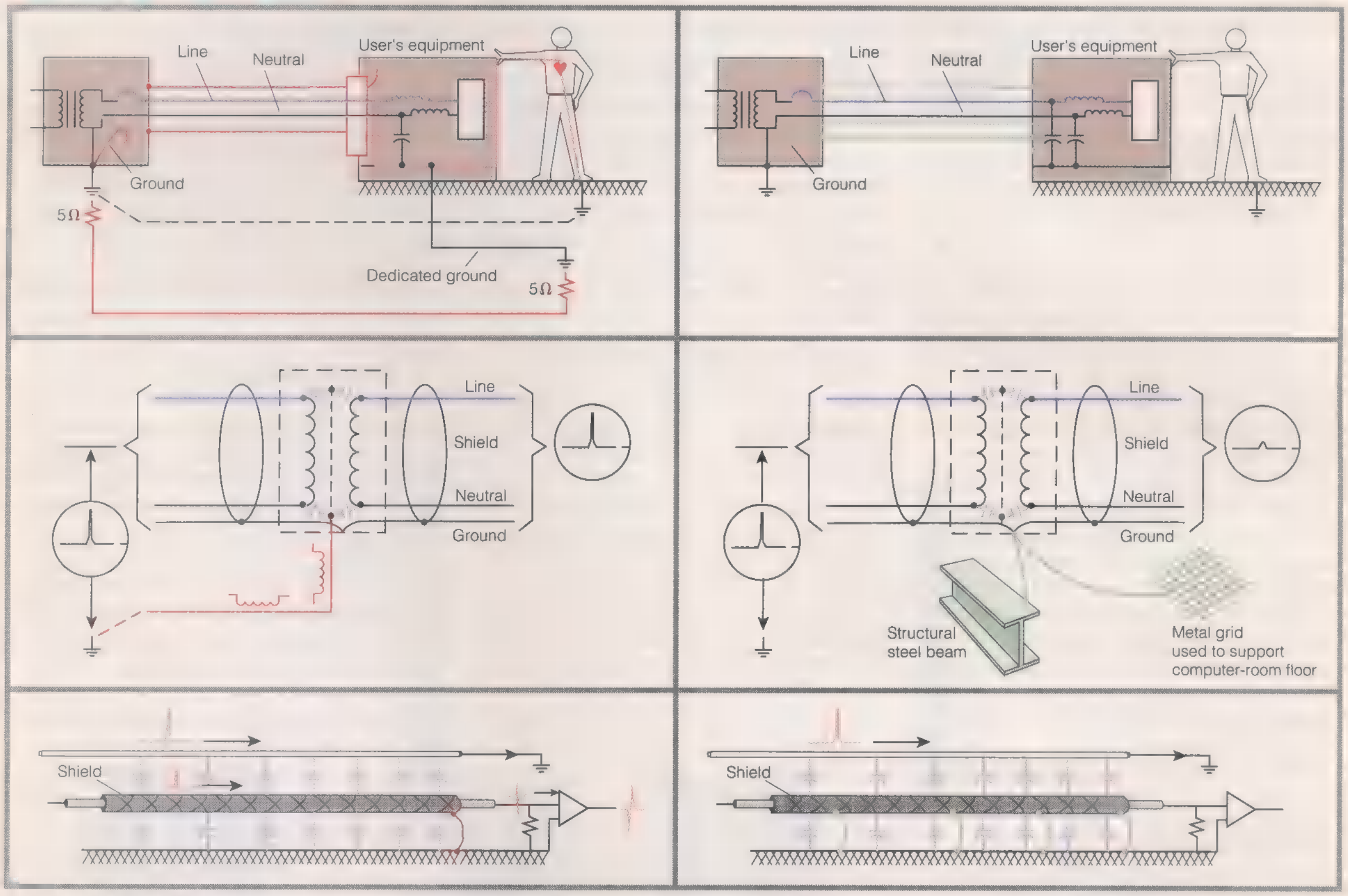
All too often, this advice is overlooked. Yet ignoring EMC is the major reason for the decline in equipment performance and reliability as newer generations of equipment rely on weaker signals at higher data rates.

LANs are the latest example of how EMC is often ignored. First, unshielded wires, though highly susceptible to EMI, are frequently used to reduce system cost. Also, long lengths are run through office buildings without regard for grounding concerns, increasing the cable's exposure to an uncertain world. Finally, conducted and/or coupled radiative noise increasingly jeopardizes LAN reliability at the higher megahertz data rates.

To prevent problems, equipment must be designed for compatibility with grounding concepts such as those described in the publications of the U.S. Department of Commerce (Federal Information Processing Standards Publication 94, FIPS PUB 94), the Department of Defense (Military Handbook MIL-HDBK-419A), the IEEE Industry Application Society (the soon-to-be-published IEEE Emerald Book) and Henry Ott's book. Similarly, those whose job it is to install a new system must be equally familiar with the concepts in such works.

As things stand, a systems engineer cannot assume that a facility's grounding will suffice for reliable operation of sensitive electronic equipment and systems. Thus, in designing a working environment within any facility, a system engineer is wise to ensure its correct operation, regardless of the state of the facility's internal power system.

Grounding do's and don'ts

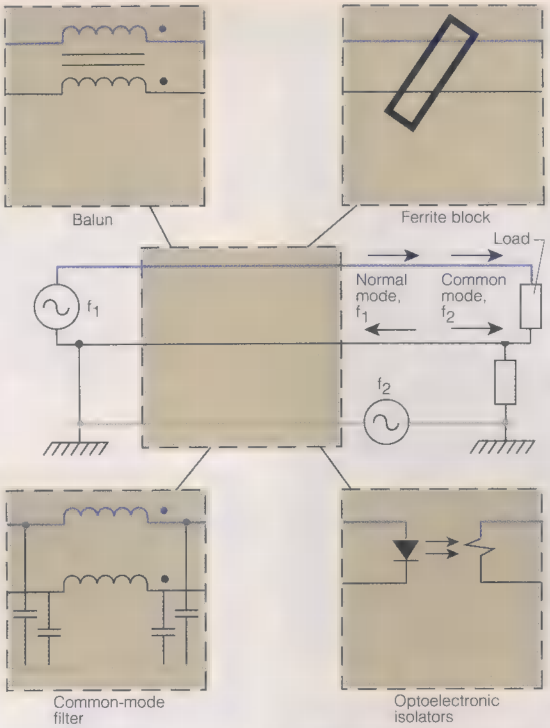


[3] Substituting a dedicated computer ground (top left) for the wire between the equipment and the power source's neutral grounding point (top right) neither conforms to code nor ensures safety or noise-free operation. When the equipment is not attached to the neutral grounding point and an insulating bushing is used at the user's equipment, an equipment short could prove fatal; the lethal current would not all be drawn from the power line and so a life-saving circuit breaker might not trip. The blocking effect of a long ground return's self-inductance (center left) makes transformer shielding ineffective and lets noise pass, while grounding the shield with a short wire to a system ground reference (center right) solves the problem. Single-point grounding of data cable shields (bottom left) seldom succeeds above 1–10 MHz because of capacitive coupling, whereas multipoint grounding (bottom right) is effective in grounding induced noise signals.

To prevent future noise problems when bringing in a new system, a good design rule is to make sure that inductances/impedances in any existing or newly installed ground lines are compatible with signal reference-ground requirements. For new lines, be certain to design the path so that resonances will not occur and there will be no significant voltage drops at any frequency of interest.

It is best to use the power grounding (safety) conductor for power grounding only. For signal-reference ground, use a separate, low-impedance path whenever possible. If possible, use separate grounding buses for digital signals, for analog signals, and to ground noise. Each bus should be terminated at the same equipment-grounding conductor terminal of the applicable derived system or service, per NEC. To minimize mutual inductances, minimize loop areas.

In computer rooms and military type communications facilities, multipoint grounding of cables is typically used to ensure a 0-V signal-reference ground, and a low-inductance ground path to ensure zero voltage drops at all frequencies. This approach is typically used when signals and/or noise are greater than about 1 MHz and when systems employ complex digital logic. Also, bonding leads must properly designed and short.



[4] Common-mode noise can be blocked by a number of means. The traditional common-mode filter diverts noise into the ground. Optoelectronic isolators are the most effective, but also the most expensive.

When using single-point grounding, ground-potential–equalizing conductors between equipment, and/or isolated grounds (NEC 250-74, Exception No. 4), remember that the effective length of the grounding conductor is limited by reactance relative to frequency and by exposure to EMI along the path of the conductor. To prevent communications EMI, at least specify and buy shielded cables, devices and equipment and be certain that the shield is grounded properly.

One of the best ways to prevent EMI radiative coupling is to use an optical-fiber bus. Optical-fiber buses should be used for expanding large, high-value corporate systems, especially as LAN data transmission rates are expected to increase.

A shielded isolation transformer controls common-mode noise and may also be used to establish a new ground reference point as an NEC separately derived source. Filters can often be used for noise immunity and emission control, but be careful to avoid signal-reference ground "pollution."

REMEDIAL CONSIDERATIONS. When radiated interference problems occur, separation—moving the equipment away from the suspected source of interference—is a classical first attempt at a solution, but one of growing futility in today's EMI-crowded workspace.

It is better to eliminate ground currents at their source and/or to isolate noise sources from susceptible equipment. The first step in eliminating ground noise, as mentioned previously, is to see that the conduit system is not used for signal-reference ground.

Noise filters and/or decouplers can be effective if used properly. But be careful where the noise or harmonics are dumped, in case the signal-reference ground become polluted. It may be possible to use baluns, ferrite cores, common-mode chokes, or optoisolators [Fig. 4]. Whether or not this can be done cost-effectively, especially for a small commercial or industrial environment using standard cables, depends on operating frequency.

> When installing new computer networks, be careful not to trade in old wired problems for new wireless ones

Retrofitting shielded isolation transformers can be an economical fix, above all where rewiring is prohibitive. When rewiring is an acceptable option, optical-fiber cables will be the surest solution, especially for large systems with megahertz data-transmission rates. Another remedy for data communications is to use modems to replace noisy, directly wired links.

Wireless networking looks temptingly devoid of ground-loop problems. But be careful not to trade in old wired problems for new wireless problems. While grounding may be simplified, interference from broadcast signals must be avoided. Even when infrared signals are the wireless medium, the fact that an electronic system can be moved, almost at random, to a place where it may interfere with both transmission and grounding conditions can wreak intermittent havoc on an operation.

TO PROBE FURTHER. The *National Electrical Code Handbook* (National Fire Protection Association, Quincy, Mass., 1990) is, of course the absolute authority on safety and power grounding. It is priced at $65 and can be ordered from the National Fire Protection Association, 1 Batterymarch Park, Quincy, Mass. 02269; 1-800-344-3555. A new handbook will be available in December 1992. Two important sources of information on maintaining power quality in a facility are *Guideline on Electrical Power for ADP Installations*, Federal Information Processing Standards Publication 94 (FIPS PUB 94, U.S. Department of Commerce, 1983) and the soon-to-be-published IEEE Emerald Book, *IEEE Recommended Practice for Powering and Grounding Sensitive Electronic Equipment*. FIPS PUB 94 costs $26 and may be ordered from the National Technical Information Service (NTIS); 1-800-533-NTIS. The IEEE Emerald Book is not yet approved and will be submitted to the board in June 1992. Presently, it is available in draft form from IEEE Publication Sales for $31; the order number is DS 01586; 1-800-678-IEEE. The Department of Defense's useful and comprehensive Military Handbook *Grounding, Bonding, and Shielding for Electronic Equipments and Facilities*, MIL-HDBK-419A, 1987, consists of two volumes, "Basic Theory" and "Applications." The handbook is available from the Defense Printing Service, Standardizations Documents Order Desk. The service may be reached at 215-697-3321, or fax to 215-697-2978. IEEE Standard 518-1982 *IEEE Guide for the Installation of Electrical Equipment to Minimize Electrical Noise Inputs to Controllers from External Sources* may also be ordered from IEEE Publication Sales; its price is $31 and its order number is SH 08813. Henry Ott's *Noise Reduction Techniques in Electronic Systems*, second edition (John Wiley & Sons, New York, 1988), is a comprehensive and highly readable text.

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The future is in the PC cards

Originally designed for harsh environments, these compact cards have evolved into a standard for handheld systems

The industrial use of IC memory cards began about 10 years ago on the factory floor, where tape and disk drives used for data logging had a tough job dealing with oil spray and vibration. At that time, the big attraction of those cards was their ruggedness. Today, their small size and low power consumption count even more in pushing the successors of those early cards into key roles in all sorts of handheld equipment—from computers and data-acquisition systems to pocket organizers and even digital snapshot cameras [Fig. 1].

In the brief period since the introduction of the first battery-backed memory cards, three events have propelled their credit-card-sized descendants to prominence:

- A standard has been written for 68-pin personal computer cards, known as PC cards, that allows them to act as peripherals, such as modems and network ports, as well as storage devices.
- Flash-type nonvolatile memory chips of very high capacity have come into being, making possible reasonably priced PC cards that store as much as some hard disks.
- Palmtop and notebook computers have emerged as sizeable businesses, which are providing the volume needed to cut costs.

In conjunction with the fundamental advantages of low power consumption and physical toughness, this convergence of factors is leading many mainstream semiconductor, software computer, and consumer electronics vendors to introduce both end-user products and off-the-shelf components and software, facilitating the widespread adoption of PC card technology. The movement is impacting both industrial and commercial product developers, promising an entire new generation of portable equipment.

THE STANDARD. Key to the impact of the PC card is the conceptual framework established by the Personal Computer Memory Card International Association (PCMCIA) and the Japan Electronic Industry Development Association (Jeida). Together the groups have developed a standard for a 68-pin credit-card-sized module that addresses the needs of applications ranging from computers to digital cameras. By way of comparison, IC memory cards had been around for about eight years before they caught on in 1990—the year in which the first version of the standard was released.

Release 1.0 of the standard specified the physical, electrical, and data-format properties for memory-type PC cards. The standard's framework is based on a header, called a card information structure (CIS), which is analogous to the partition table of a hard disk. Any system that complies with the standard can read the CIS to determine which partitions it can access in terms of its ability to handle each partition's memory technology and data organization or file system.

Last September, Release 2.0 of the standard added I/O capability along with a new feature called XIP. The I/O capability provides the first industry-standard bus-expansion slot for portables. With it, peripherals like modems and local-area network (LAN) adapters no longer need to be proprietary devices. For that reason alone, many portable-system original-equipment manufacturers (OEMs) are designing PCMCIA/Jeida slots into machines slated for 1992 introduction.

> PC cards can serve as peripherals, like modems, as well as mass-storage devices

The XIP capability of PCMCIA 2.0 stands for eXecute In Place, and refers to the ability of a system to execute program code directly from a memory card without first copying the code into system random-access memory (RAM). Based on the Lotus-Intel-Microsoft expanded memory protocol LIM/EMS 4.0, XIP is particularly appropriate for low-cost systems, where it is always desirable to minimize the required RAM. By executing from the read-only memory (ROM) on the card, XIP allows all of a system's RAM to be used for data storage.

For high-end applications, the PCMCIA is discussing a new mode called EXIP, which allows the 80386 and other advanced microprocessors to operate in protected mode, directly mapping in large regions of the card's address space. Though some advantages exist for large programs operating in this mode, there are disadvantages as well. In particular, executing programs from ROM is much slower than executing them from fast cache memory.

Overall, the outlook for XIP is unclear. It

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Defining terms

Card drive: a peripheral device for a personal or industrial computer that allows memory cards to be read and/or written. Card drive interfaces often emulate those of disk drives.

Card information structure (CIS): the header at the beginning of a PCMCIA/Jeida format memory card, which supplies basic format and card technology information to the system using the card. CIS is also called the metaformat.

Data format: the organization of information on a storage medium, typically hierarchical, ranging from specifications for the low-level data-recording format to high-level file-system organization.

Electrostatic discharge (ESD): the rapid discharge of accumulated static charge; a reliability concern in consumer electronics because of uncontrolled low-humidity environments.

Flash memory: a family of inexpensive, nonvolatile memory technologies that are electrically erasable and reprogrammable in circuit. Flash memory differs from electrically erasable memory (EEPROM) in that it must be erased in blocks, whereas EEPROMs allow individual bytes to be erased.

I/O card: a peripheral expansion function such as a modem or network interface packaged and designed in such a manner as to operate in a PCMCIA version 2.0 card slot. Current uses are primarily in palmtop and notebook PCs.

Jeida: Japan Electronic Industry Development Association.

Notebook PC: a portable personal computer in the 2–4-kg range, about 230 by 280 mm in area and 25 to 50 mm thick. Units in the 1- to 2-kg weight range are often referred to as "sub-notebook" PCs.

Palmtop PC: a portable personal computer, generally weighing under 0.5 kg.

PC card: any 68-pin memory or I/O card complying with the PCMCIA/Jeida specifications.

PCMCIA: Personal Computer Memory Card International Association.

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[1] A memory-type PC card is being used with an external card reader/writer from Databook Inc., Ithaca, N.Y., to transfer data between a desktop computer and a palmtop PC from Poqet Computer Corp., Sunnyvale, Calif. (left). The military-grade RHC-44 handheld computer from Paravant Computer Systems Inc., West Melbourne, Fla. (top left), is sealed to permit "underwater" operation, and withstands extremes of temperature, shock, and vibration during operation. To automate data collection by meter readers, Itron Inc., Spokane, Wash., has developed a specially equipped and programmed handheld computer, shown above in a parking meter application.

will probably enjoy its greatest success in low-end devices, but even there a chicken-and-egg situation prevails. Software vendors are unlikely to port their programs to XIP without a large installed base of PCs supporting it. But as RAM and flash memory cards get cheaper, the relative importance of saving system RAM is reduced. OEMs, unsure of whether their customers will need it in the long run, are playing it safe and designing it into their PCs. Once an installed base has been created, XIP may indeed catch on.

At present, three standard PC card thicknesses have been defined: 3.3, 5.0, and 10.5 mm, known respectively as Types I, II, and III. A Type IV card with a thickness of about 15 mm has been proposed but not yet accepted. Whereas the thinner cards are used mostly for solid-state memory, the thicker ones may house rotating magnetic media, and can also be used for network adapters and modems—devices with built-in connectors.

FLASH AHEAD. The current state of the art in flash memory chips—a type of electrically erasable nonvolatile memory that can be made with very high density—is 8M bits per chip. For that reason, they have the potential to replace low-capacity magnetic disks. Cards of up to 20M-byte capacity are available today in volume at about US $30 per megabyte, and that price is expected to drop fairly quickly in the near future.

Generally, because of their write/erase properties, special device driver software, like the Flash File System from Microsoft Corp., Redmond, Wash., is required to make flash memory cards act like disks.

One exception to that rule is the mass storage flash technology being marketed by SunDisk Corp., a Santa Clara, Calif., start-up, and AT&T Microelectronics, Allentown, Pa. Their proprietary, error-corrected, bit-serial technology allows them to emulate a conventional MS-DOS PC hard disk—including the 512-byte (sector) erase block size—with no need for special software drivers. The product comes in 10M- and 20M-byte versions with an AT attachment (ATA) interface integrated into a standard PCMCIA/Jeida I/O Card. It sells for $60 to $70 per megabyte in high volume.

The SunDisk technique trades off the complexity of carrying the ATA drive logic in each card for the advantage of using standard disk-drive device-driver software. How these tradeoffs, which are promoted as supporting an intrinsically inexpensive and manufacturable memory technology, will ultimately fare in the market remains to be seen. Several major OEMs, including IBM Corp., have announced products incorporating these cards.

Many hard-disk vendors, including Integral Peripherals Inc., Boulder, Colo., and MiniStor Peripherals, San Jose, Calif., have announced 1.8-inch rotating drives packaged in PCMCIA Type III (10.5-mm) cards. These are a further indication of the broad applicability and acceptance of the PCMCIA/Jeida sockets both for mass storage and I/O communication.

PALMS AWAY. The palmtop PC, a portable computer weighing about half a kilogram, has a unique symbiotic relationship with the PC card. On the one hand, the card made the computers possible; on the other, high production volumes of the computers are making the cards affordable. If it were not for the memory cards they use instead of disk drives, it is unlikely that palmtops could get enough life out of their AA cells to succeed in the marketplace.

Palmtop computers typically have undersized keyboards and are not intended for massive data entry (although this article is being written on a Poqet PC during an airplane flight). Often palmtops contain built-in applications: the 0.31-kg HP-95 from Hewlett-Packard Co., Palo Alto, Calif., for example, comes with the Lotus 1-2-3 spreadsheet in ROM. But what really makes them useful is the fact that, with the help of PC cards, they can share programs and data with desktop computers, as shown in Fig. 1.

A related class of product, the "subnotebook" PC, exemplified by the FM-R-CARD, from Fujitsu Ltd., Tokyo, offers a full-size notebook PC keyboard and display in a package weighing approximately 1 kg. These

products can either use memory cards to maximize battery life or employ the new 1.8-inch disk drives, when they become available, for increased storage capacity.

BEYOND MEMORY. Although memory applications gave PC cards their start, the introduction last September of an industry I/O card standard will profoundly impact the portable computer marketplace.

Prior to such a standard, owners of notebook computers had to purchase expansion options like modems and LAN adapters from the manufacturers of their computers because no industry standard for these cards existed. Further, system vendors were forced to build in functions like serial and printer ports, which not every user needed. That had the side effects of adding cost and cluttering up the back panels of notebook PCs with connectors.

With the advent of an industry-standard I/O card, these functions can be provided by third parties; system vendors merely have to provide slots into which the appropriate cards can be plugged. This concept is being embraced by the full spectrum of personal computer manufacturers—including industry leaders like AT&T (NCR Safari Systems Division), Dell, Sharp, Toshiba, and numerous clone makers. And what enables these leaders to adopt this technology is the availability of off-the-shelf card interface chips and system software from such members of the established infrastructure as Award Software, Fujitsu, Intel, Microsoft, Mitsubishi, Phoenix/Quadtel, Vadem, and VLSI Technology, among others.

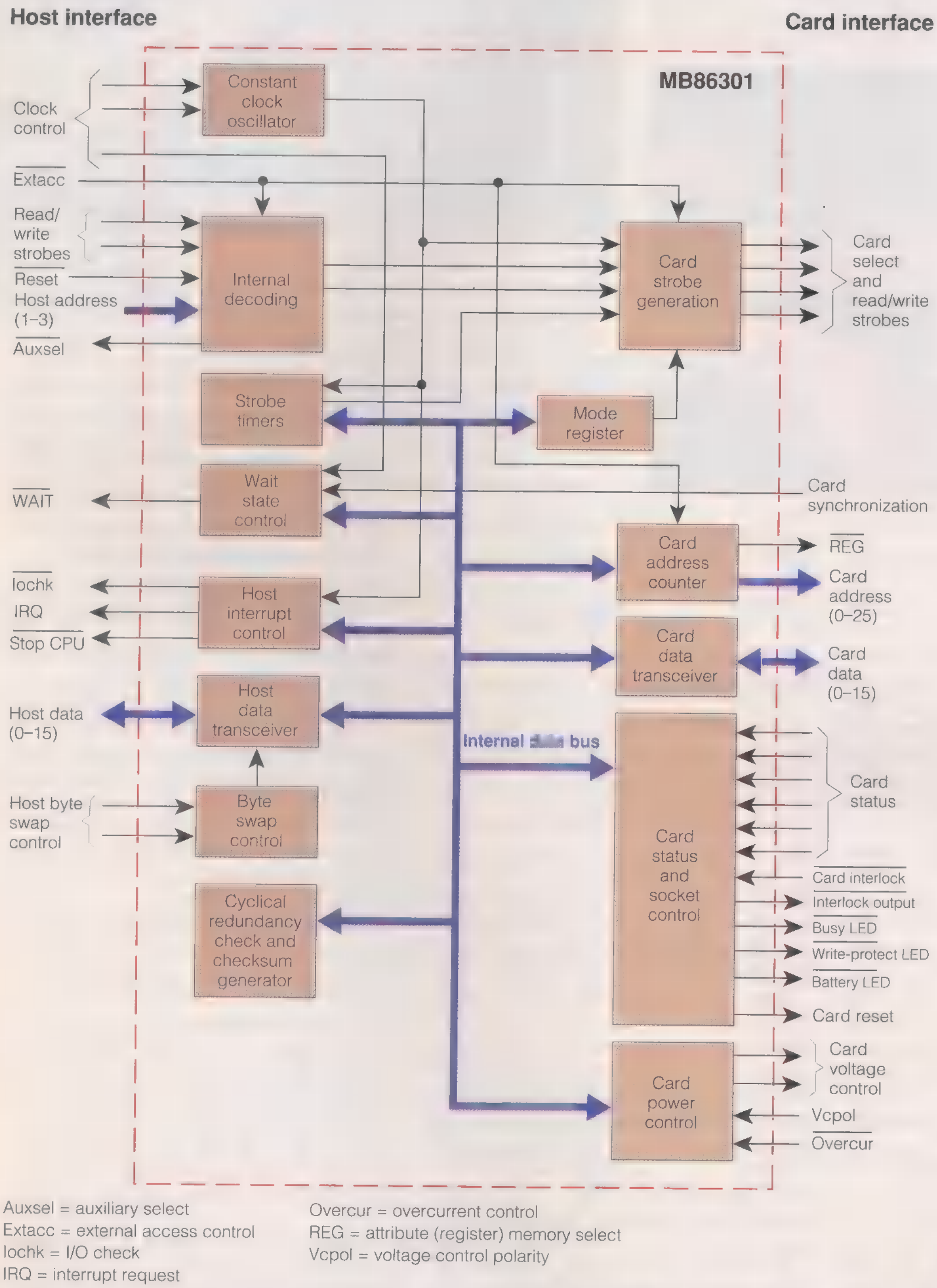
HARDWARE ISSUES. Which interface—simple or complex—to use for a card depends on the type of card. For cards using memory technologies that have typically required a dedicated programmer, such as a programmable ROM (PROM), signals may have to be latched and specific programming voltages switched. Additionally, I/O cards require multiplexing of signals on some of the socket's pins, as these signals are redefined for I/O cards.

Moreover, if "hot" insertion and removal are to be permitted—that is, if the user is to be allowed to insert and remove the card while the system is operating—then certain system-level protocols, such as card power-up and power-down, and buffering of bused signals to cards must be observed.

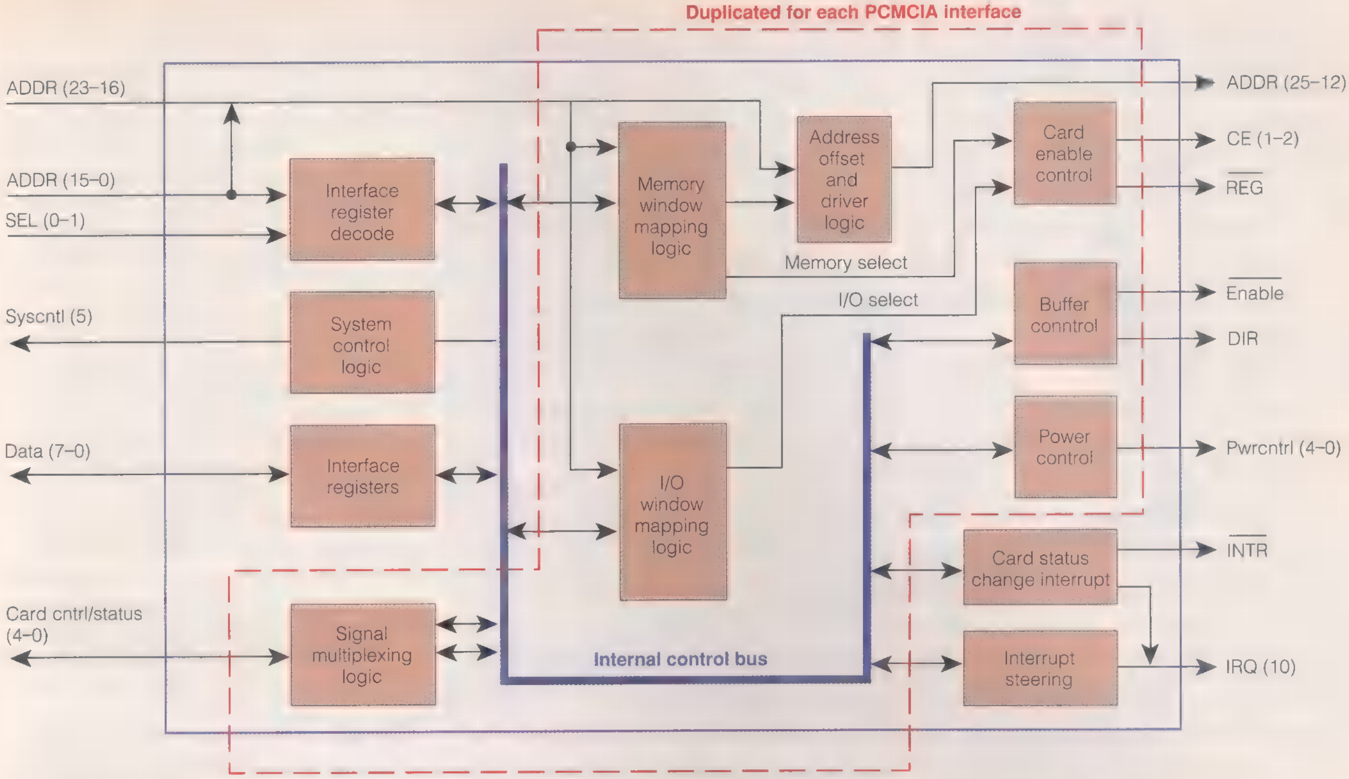
By far the simplest type of cards to interface are memory cards based on ROMs or static RAMs (SRAMs). The SRAMs require only a 3- or 5-V supply and use simple strobed read/write cycles, directly compatible with the timing of most microprocessors. ROM cards, which are typically used to distribute software or databases, are currently available in capacities up to 32M bytes, and can be read by any system supporting SRAM types of read cycles.

More demanding, if writing is required, are flash memory cards based on older flash memory chips, which do not include data latches. For such chips, the interface circuitry must latch the data during the write cycle, and may also have to set the length of the programming pulse. Newer flash chips have internal data latches and timers.

Most of the flash chips used in cards are command driven; they require specific commands to be written to them to enable programming and block erase. Some flash chips require strobes to be held in a specified logic state during programming, which varies from 1 to 10 μs per byte. Typical flash memories are read in the same way as SRAM or ROM cards, often allowing



[2] Intended for use in both personal computers and embedded systems, the Fujitsu MB86301 features a register-based interface architecture. For that reason, it works only with memory-type PC cards.



ADDR = address
Card cntrl/status = card control and status lines
CE = card enable
DIR = card data bus buffer direction
Enable = card data bus buffer enable
INTR = interrupt request to CPU (connects to EXTSMI on Intel 386SL)
IRQ = interrupt request
PCMCIA = Personal Computer Memory Card International Association
Pwrcntrl = power control
REG = attribute (register) memory select
SEL = strapping option for card socket mapping
Syscntl = system control

[3] Thanks to its window-mapping architecture, the Intel 82365SL interface chip supports all aspects of PCMCIA 2.0, including memory, I/O, XIP, and EXIP. It has been optimized for use with Intel's 386SL microprocessor.

them to be used as read-only cards in systems that can write only to SRAM-type cards.

Ultraviolet-erasable PROMs (EPROMs) and one-time programmable ROMs (OTPROMs) need latched address, data, and control signals, as well as careful observance of programming pulse width and timing rules to ensure reliability and avoid device damage. The cards read like SRAM or ROM cards as well.

INTERFACING CHIPS. One important factor smoothing the way for PC cards is the availability of single-chip card interfaces. These products not only simplify the equipment design, but also solve the space and power dissipation problems associated with discrete logic implementations—particularly for the more complex interfaces required to implement memory mapping, I/O card interfacing, flash card support, XIP, and hardware error detection.

In general, only the simplest SRAM/ROM card interfaces will be implemented in discrete logic. In most cases, designers will choose one of the two main types of interface chips. The register-based approach, exemplified by the Fujitsu MB86301 chip, is for memory cards only [Fig. 2]. It reads and writes data at a single I/O address, and includes error detection and buffering. Fujitsu supplies the MB86301 bundled with PCMCIA-2.0 memory card software from Databook Inc., Ithaca, N.Y.

The other main approach, memory mapping, maps part of the card's memory into the processor's address space. Using this approach is the 82365SL chip from Intel Corp., Santa Clara, Calif. It permits XIP and supports PCMCIA/Jeida-compatible I/O card operation. In addition, it implements the hardware portion of Intel's trademarked ExCA Exchangeable Card Architecture baseline implementation of the PCMCIA standard, which also includes specific minimum software requirements [Fig. 3].

> Several vendors pack 1.8-inch rotating magnetic drives in 10.5-mm PC cards

In addition to the card interface logic, PROM and most flash cards require a programmable power supply. These can be constructed using commercially available switching regulator ICs from Maxim Integrated Products, Sunnyvale, Calif., and Texas Instruments Inc., Dallas, among many others.

An exception is the SunDisk/AT&T family of flash cards, which will be offered with internal dc-dc converters, allowing them to operate on 5 V only. Other companies, including Advanced Micro Devices Inc., Sunnyvale, Calif., also have demonstrated flash technologies with direct 5-V programming.

Regardless of their specific technology, all writable cards benefit from system power monitoring, which ensures that they are isolated from transient signals, especially during system power-up and power-down. This is particularly important for guaranteeing data integrity in cards based on SRAMs.

MAINTAINING RELIABILITY. Besides the usual common-sense precautions, two actions are required to enhance the reliability of PC cards: monitor the programming power supply and protect the card against electrostatic discharge (ESD).

Supply monitoring—that is, detecting excessive programming currents—is important to protect against card failures (shorts) and the use of cards with programming current requirements that exceed the supply's capability. Some of the card interface large-scale integrated circuits have both registered power-supply control outputs and power-

supply status inputs.

Protection against electrostatic discharge is a critical, and often neglected, reliability issue for PC cards. With users free to insert or remove cards after walking across a carpet, the potential for damage is obvious. It is essential, therefore, that the product be designed and tested to withstand repeated static discharges. The problem does not often arise with DRAM expansion cards ["Other memory-card standards," right] because they are usually installed and then left in place.

SOFTWARE ISSUES. When designing or specifying memory card software, the key question the designer must address is compatibility: ensuring that a card that has been written to by one system will be readable by another. Central to this question is the software governing the format of the data on the card. The PCMCIA/Jeida standard specifies a uniform approach, the card information structure, or CIS (also called the metaformat), which describes the data organization within each card partition in a way readable by any system complying with the standard.

MS-DOS PCs must implement a CIS interpreter along with the required file systems and device drivers. The PC card system software not only handles the various aspects of the data-format standard, but also serves as the link between the cards and the operating system and application programs on the PC.

For a non-PC system to achieve seamless file interchange with MS-DOS PCs, it must emulate one of the file systems so as to present the DOS PC with a data format that the latter is equipped to read and write.

Already published by the PCMCIA and Jeida is a low-level command set called BIOS Socket Services, which is intended to reside in ROM on a PC's motherboard where it will isolate the higher-level software from the particulars of the socket hardware.

A second software layer, Card Services, in the course of being finalized, will provide a higher read-write-copy-erase level of abstraction. When it is published, Card Services will be the interface used by utility programs like formatters and I/O card device drivers. In the short term, Microsoft and others are supporting PC cards with device drivers that work with no need for ROMs—the same approach used by retrofit card drives.

Device driver software directly accessing the hardware has been used in the MS-DOS world for a long time. This approach is acceptable so long as compatibility is defined as interchanging memory cards among systems, and I/O card support is limited to I/O cards that are controlled directly by application programs or existing loadable device drivers. With loadable drivers, though, the end user may have to go through an installation process before using a new card technology.

Besides eliminating the user installation process, Card Services will allow special device drivers for new I/O cards, which can benefit from abstracted control over the socket hardware. Another advantage will be the ability to hook in technology-specific drivers to permit the easy upgrading to future generations of cards in a system-independent manner.

EXCHANGING DATA. As memory-card-based portables proliferate, there will be an increasing demand for card reader/writers to provide convenient data transfer between desktop and portable PCs. The availability of highly integrated PC card controller chips is expected to drive the retail prices of these drives down significantly from their present level of about $400 by year-end. Both external (serial or parallel port) and internal (bus expansion) versions are currently available.

A second category of reader/writer, or card drive, is targeted at industrial and embedded systems, where ruggedness matters most. Sealed and gasketed units as well as industrial bus plug-in types for the VME and STD buses are available.

> All the elements are in place now for a mass market in PC-card–equipped products

Other memory-card standards

The PC cards described in this article are not the only credit-card-sized memory devices on the market today. A second category of card, containing dynamic random-access memory (DRAM), has also been standardized. The DRAM cards, which come in 60-pin, and more recently, 88-pin versions, are used primarily for main memory expansion, not data transfer or I/O. The principal bodies defining DRAM card standards are the Electronic Industries Association's Joint Electron Devices Engineering Council (Jedec) and the Japan Electronic Industry Development Association (Jeida). The Personal Computer Memory Card International Association (PCMCIA) recognizes and contributes to the work of Jedec and Jeida in this area.

These DRAM cards represent a significant improvement over "loose components" or single in-line memory modules (SIMMs), because they encourage the design of computers with easily expandable memories. Even the least technical and clumsiest of end users should be able to install a DRAM card into its slot.

Further, DRAMs packaged in the Jedec cards are provided a much higher degree of mechanical and ESD protection than was previously available. Because these cards are essentially a high-density repackaging of current DRAM "in-line" module technology, they are not addressed in detail in this article.

The combination of increasing storage capacities, falling memory prices, and a standardized expansion slot for portables (I/O cards) is accelerating the proliferation of portable computer, consumer, and industrial products. Thanks to the industry's broad acceptance of the PCMCIA/Jeida standard, those products will work well with one another and will integrate smoothly into the existing computer environment.

This year, for the first time, all the elements needed to support a mass market for PC-card–equipped products are in place. As mass market acceptance pushes prices down and encourages the development of supporting products, commercial and industrial applications will expand as well.

TO PROBE FURTHER. *Memory Card Systems and Design*, a design-oriented magazine, is an excellent source of up-to-the-minute technical articles and advertising relating to the PC card industry. For information, contact Kathy Kriner, Editor/Publisher, at 6300 South Syracuse, Suite 650, Englewood, Colo. 80111-9912; 303-220-0600.

The Personal Computer Memory Card International Association (PCMCIA) publishes hardware and software technical specifications, a member company resource (product) reference guide, and a range of industry/market background materials. The PCMCIA Administrative Office is located at 1030G East Duane Ave., Sunnyvale, Calif. 94086; 408-720-0107.

Engineers in the Orient may find it more convenient to obtain information from the Japan Electronic Industry Development Association (Jeida) at Kikai Shinko Kaikan 313, 3-5-8, Shibakoen, Minato-ku, Tokyo 105, Japan; (81+3) 433 1923. Jeida publishes many technical specifications, including WG-9, the Jeida memory card working group documents.

The Joint Electron Device Engineering Council (Jedec) publishes many standards relating to memory and programmable logic devices. It issues separate documents for mechanical and electrical specifications. Jedec is located at 2001 Pennsylvania Ave., N.W., Washington, D.C. 20006; 202-457-4971.

ABOUT THE AUTHOR. Daniel Sternglass is the founder and chairman of Databook Inc., Ithaca, N.Y., a maker of memory card peripherals and related system software. He is a founding board member of the Personal Computer Memory Card International Association, headed the Software Working Group in 1991, and was the technical cochairman in 1990 and 1991. Sternglass currently co-chairs the Joint Electron Device Engineering Council JC-42.5 memory card software subgroup, TG-25. Before founding Databook, he held computer engineering and engineering management positions in several industrial, aerospace, graphic process equipment, and automotive companies. He holds three patents related to memory card application. ◆

Conducting polymers

These lightweight, easily processed materials are showing up in batteries, overcurrent protection devices, and more

Synthetic polymers, whose long molecules string together hundreds of identical structural units, have been insulating electric equipment since the turn of the century. The later fabrication, in the 1970s, of polymers with usefully high electrical conductivity stirred intense interest in the research and development community. By now these polymers are showing commercial promise in such areas as power equipment, batteries, microelectronics, shielding against electromagnetic interference, and coatings, not to mention micromachines and adhesives.

Polymers as a group are relatively light and easy to process. The conducting type is, in addition, mechanically and electrically compatible with such conductors as copper and such semiconductors as silicon. Typical conductivities of the newest conducting polymers run anywhere between 10^{-4} and 10^{7} siemens per meter, compared with 1.1×10^{7} S/m for copper and 10^{-2} to 1 S/m for lightly doped silicon, both at room temperature.

To date, the addition of conducting fillers such as copper and carbon black to conventional polymers has been the only way to produce easy-to-process materials having some measurable electrical conductivity. The cost of the technique is undoubtedly low, but problems can arise in the form of surface corrosion, uneven mixing, reduced mechanical properties, and incompatibility of the filler with the polymer matrix. Careful selection of materials and processing methods for a given application can reduce the consequences of these problems.

Conducting polymers are prepared in two steps, which can be simultaneous or sequential. First, the polymer is formed from its starting material by a conventional chemical polymerization process. The molecular structure of such polymers typically has considerable delocalization of electrons along the polymer chains. This structure is also conducive to formation of energy bands, from and to which charge carriers can be easily removed or added.

The second step in the preparation of conducting polymers is the creation of charge carriers by reaction with a chemical oxidizing or reducing agent. The first withdraws electrons, the second adds them. Among the common dopants are halogens (like iodine or bromine), transition element cations (like ferric or ceric cations), organic oxidizing agents (like chloranil or dichlorodicyanoquinone), and alkali metals (like sodium or potassium).

Doping can also be accomplished by adding or removing electrons electrochemically. In this case charge is balanced by incorporating ions from the electrolyte. The choice of dopant and doping method determines the polymer's electrical and optical properties and, in some cases, also influences its processing characteristics.

SATURATES AT HIGH DOPING. The electrical conductivity of any conducting polymer can be varied over a wide range, depending on the amount and reactivity of the dopant used. To begin with, conductivity increases dramatically with dopant content, until the effect saturates or reaches a maximum at high doping levels [Fig. 1]. The doping process creates spinless charge carriers—called polarons and bipolarons—at energy levels within the bandgap. This situation contrasts with metallic conductors in which the charge carriers (electrons) have spin. Conduction overall in a macroscopic sample is thermally activated and depends exponentially on temperature, much as in semiconductors but unlike metals.

Stability and processing characteristics have been the main barriers to the commercialization of these materials. Stability pertains primarily to reactivity toward oxygen or moisture. Doped polyacetylene, one of the earliest conducting polymers, has a conductivity of 15 000 000 S/m at room temperature. But as it is also very reactive toward oxygen and moisture, it rapidly suffers irreversible loss of conductivity in the atmosphere. Several other polymers exhibit much greater stability toward ambient conditions, including polypyrrole, polyaniline, polyphenylene vinylene, and polythiophene. While not as conductive as polyacetylene, they do well enough for many applications.

The second key issue in conducting-polymer technology is ease of processing. The first conducting polymers were hard to process because of their insolubility and infusibility—they could not be easily dissolved in any common solvent and would not soften or melt at elevated temperatures. But considerable progress has been made in the past few years. Several conducting polymers can now be prepared as dispersions and applied as coatings, while others can be prepared from processible precursor polymers. A good example is the addition of a hexyl group to thiophene, which is then polymerized to form poly (3-hexylthiophene), a material that unlike poly(thiophene) itself, is readily soluble in chloroform. The precursor is purified and filmed onto a substrate by spin-coating. Subsequent heating or irradiation of the film converts the precursor to the con-

> Electric vehicles could become the biggest payoff of all for conducting-polymer batteries

Defining terms

Conducting filler: an electrically conductive material added to an insulating polymer to increase its conductivity.

Delocalization (of electrons): a situation wherein electrons are free to move (along the polymer chain) rather than be part of a bond between two atoms.

Derivatization: covalent bonding of a chemical group or groups to a polymer chain to change its processing or physical properties.

Polymer: a long molecule based on the repetition of a basic structural unit (monomer).

Polymerization, chemical (electrochemical): the creation of a long molecule from its basic structural unit by a chemical (electrochemical) process.

Precursor polymer: a polymer that is converted to the final, desired polymer by a simple process such as heating or irradiation.

Smart skin: a generic term for various technologies used to control the conductivity of the outer skin of such military equipment as aircraft and tanks.

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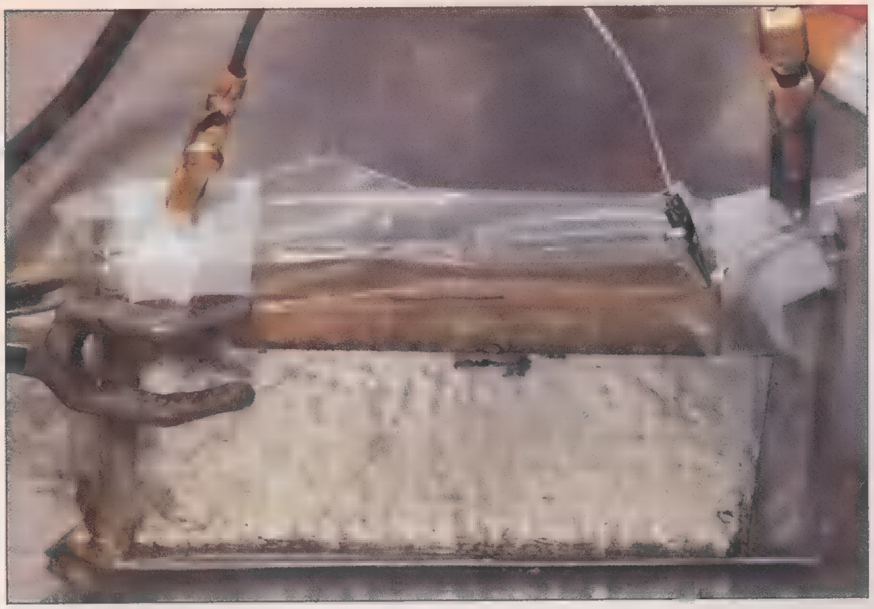


Lithium-polymer electrodes are used in this experimental battery—one-sixth the size of ■ future electric vehicle cell, under development in Westinghouse Electric Corp.'s Science and Technology Center, Pittsburgh.

ducting polymer. Many of the polymers can be blended with conventional thermoplastics, such as polyethylene or polyvinyl chloride, to produce ■ partially conducting material that is readily processed. (Thermoplastics, one of several generic types of polymers, are readily processed by extrusion or molding at elevated temperatures, unlike thermosetting resins, another category.)

These advances in stability and processability occurred during the 1980s, when academic interest in conducting polymers overflowed into development efforts in national laboratories, in the U.S. Department of Defense, and in commercial companies worldwide. Several conducting polymers are now available commercially [Table 1].

Indeed, some products have already appeared on the market. It now appears that more of these materials will be seen in an increasing number of products within the next five years [Table 2].

3-V BATTERY. The first commercial product to utilize ■ conducting polymer appeared in 1987. It was a 3-V, coin-sized primary battery manufactured by the Tokyo joint venture Bridgestone-Seiko [Fig. 2, top]. Its anode is made of a lithium-aluminum alloy, its cathode of polyaniline, and its electrolyte is an organic liquid. More recently, the German joint venture Varta-BASF, formed by Varta AG of Bad Homburg and the BASF Group of Ludwigshafen, introduced a 3-V button cell with a lithium-aluminum alloy anode, ■ polypyrrole cathode, and an organic liquid electrolyte. Both these batteries are excellent wherever low power, long life, and reliable operation are required. Their main use to date has been for computer power back-up, but they have also shown up in wristwatches, telephones, timers for videocassette recorders, and TV remote controls.

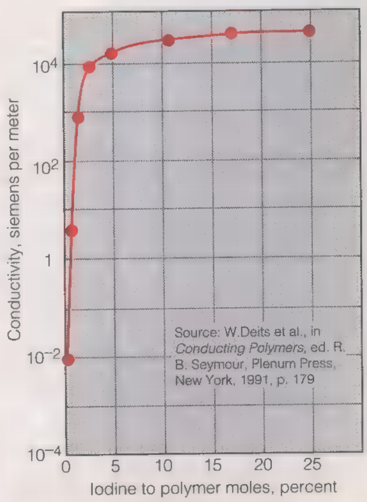
Other primary batteries feature an all-solid construction. They have ■ lithium anode separated from an inorganic, maybe titanium disulfide, cathode by an ionically conducting solid polymer, like polyethylene oxide incorporating lithium perchlorate.

Electrodes made of conducting polymer offer reliable operation plus ■ relatively low weight, resulting in increased power and energy densities (watts and joules per kilogram, respectively). The electrolyte made of ionically conducting polymer yields an all-solid, hence less hazardous battery.

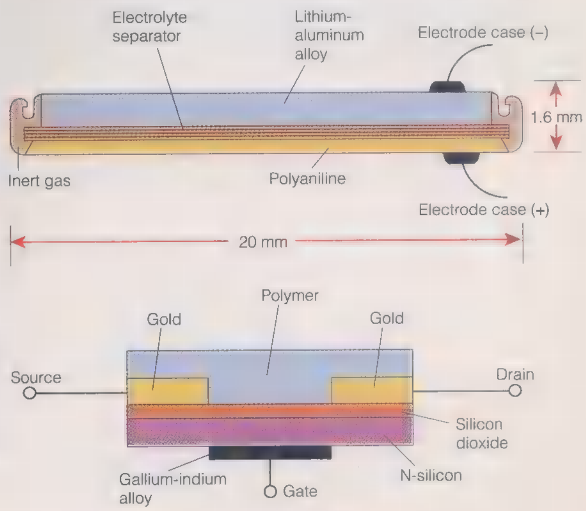
While ■ small market is being established for such primary cells, the big payoff for polymer batteries is in the rechargeable, high-power, high-rate, and lightweight areas, specifically for electric vehicles. As before, conducting polymers suit this application because of their light weight, low cost, and long life cycle. Much work remains to be done, nonetheless. The stated long-term requirements of the newly formed U.S. Advanced Battery Consortium (USABC) of Detroit, Mich., for an electric vehicle battery will be extremely difficult to meet, in that ■ combination of high power density (400 W/kg), high energy density (720 000 J/kg), and rapid recharge (three to six hours), as well as long life and low cost, are needed. At present, it appears that the only battery system theoretically capable of reaching such requirements is the lithium-polymer type. Because of the huge commercial potential of electric vehicles worldwide, many companies, national laboratories, and universities are developing conducting-polymer–based batteries, among them Switzerland's ABB, France's SAFT, and Britain's Chloride Group.

For conductive-polymer–based batteries to be suitable for the power industry, important requirements are sufficiently high current-carrying capability, long life, and mechanical strength.

Biomedical applications for conducting polymers have been commercialized by 3M, St. Paul, Minn., and Medtronic Inc., Minneapolis, Minn. The latter's product line includes polyelectrolyte "hydrogels" used in drug delivery systems and hydrated polymers used in electrodes. Elsewhere, structures similar to muscle fibers have been proposed by researchers in Italy and Japan.



[1] The conductivity of polyacetylene increases exponentially at low iodine dopant concentrations and then saturates at about 10 mole percent iodine because no more charge carriers are available.



[2] A 3-V coin-sized button cell made by Tokyo's Bridgestone-Seiko venture employs a polyaniline cathode [top]. Experimental field-effect transistors, which are being developed in several countries, contain an active thin-film layer of a conducting polymer [bottom].

They are based on the property that a conducting polymer in a fiber form undergoes dimensional changes as a result of electrochemical doping and undoping. Work results from contraction and expansion along the fiber's length.

An electrolytic capacitor featuring electrochemically prepared polypyrrole as a solid electrolyte was introduced a few years ago by Matsushita Electric Industrial Co., Kadoma City, Japan. The capacitor has excellent thermal and moisture stability and has been used in a small camcorder.

EMI SHIELDS. Milliken & Co., Spartanburg, S.C., polymerizes and dopes conducting polymers on the surface of such fabrics as nylon, cotton and polyester to produce fabrics with a range of conductivities under the trade name Contex. These materials are under intense study for use in future aircraft and tanks. They could also be used for heated clothing, shielding computers against electromagnetic interference, static dissipation in high-speed missiles, and conveyor belts that handle static-sensitive electronic and flammable articles.

Raychem Corp., Menlo Park, Calif., has been applying conducting polymers to several industrial uses, including self-regulating heat-tracing systems, leak-sensing cables and current fuses. ABB Asea Brown Boveri in Baden, Switzerland, has also developed a current-limiter, connected in series with a circuit breaker, that contains a resin with electrically conductive polymer particles. At a given temperature, the structure of the material's outer layer alters, separating the conductive particles; within a few hundred microseconds the resistance increases by a factor of 30 and the current peak is limited. On cooling, the structure returns to its original state.

Paradoxically, those shortcomings of conducting polymers that originally impeded their commercialization, namely, their lack of stability in the presence of moisture, elevated temperature, and time, have been turned to advantage in anti-theft devices. Researchers with Allied-Signal Inc., Morristown, N.J., developed response elements, or targets featuring conducting polymers in remotely readable detectors. The elements consist of a flat, small RF resonance circuit. Labels of conducting polymer are placed over the response elements or targets that are commonly attached to items in U.S. stores. When such targets are covered with a conductive label, the RF signal from a remote detector is blocked. But if the conductivity decays, because of high temperature, high humidity, and the passage of time, the RF can penetrate the label and the target's circuit absorbs and reemits RF energy—that is, a response is given.

Still other applications have not as yet been commercialized. Some seem close to commercialization, whereas others will need several more years of study and development before entering the market.

Coatings containing conductive polymers are being developed by several different groups. A polyaniline primer coat has been developed jointly by Los Alamos National Laboratories in New Mexico and the Kennedy Space Center in Florida to act as an active electronic barrier to corrosion. When overlaid with a conventional durable topcoat, such as an epoxy, the coating has been shown to protect steel against salt, pollutants, and other harsh environments.

The fact that many conducting polymers are semiconductors in the undoped or lightly doped state has prompted proposals for their use in microelectronics. So both industrial and academic groups are pursuing their use in semiconductor devices and especially field-effect transistors (FETs). For a FET's active layer—the semiconducting layer between the source and drain electrodes—micrometer-thick films are required. Advances within the last few years have made it possible to prepare films as thin as this from the polymers with techniques that are standard in the semiconductor industry, such as spin coating or thermal evaporation.

For instance, the FET in Fig. 2 was prepared by spin-coating a solution of a precursor polymer on a substrate having the required electrode pattern. To convert it into a conducting polymer, the precursor was heated in a dilute stream of hydrogen chloride gas. Until recently the carrier mobilities of such polymer FETs were only 10^{-6} to 10^{-4} cm^2/V-s. Those are several orders of magnitude below the mobilities of a silicon-based device, restricting the polymeric FETs to use at relatively low frequencies. However, recent work at CNRS in Paris has improved mobilities to 10^{-1} cm^2/V-s. This development, since conducting polymers readily lend themselves to the creation of very large arrays of devices, opens the way to uses such as flat-panel color displays for computers and possibly flat color television screens when tied to a liquid-crystal matrix.

SOLAR CELLS. Since conducting polymers can be doped to form n- and p-type semiconductors, they could be turned into solar cells. Phototherm Inc., Athol, Mass., has claimed that this kind of solar cell could be much cheaper than either conventional models or indeed conventionally generated electricity (4–5¢/kWh, as against 10¢/kWh). To date, the poor stability of conducting-polymer solar cells is preventing their use, but when this problem is solved, the potential exists for very rapid coextrusion of n- and p-type semiconductor polymers at low cost.

Several possible applications of conducting polymers stem from the changes in their properties between the doped and undoped states. In fact, shelf-life indicators based on the electronic changes between those two states were mentioned earlier as already commercialized.

Aircraft uses are being investigated at both Lockheed Corp., Calabasas, Calif., and General Dynamics Corp., Falls Church, Va. The possibilities include static charge dissipation, lightning strike protection, embedded antennas, sensors, de-icers and anti-radar aids—technologies generically known as "smart skins." The conducting polymers would be incorporated into the aircraft structure as conducting fabrics, using the standard lay-up processes employed by the industry. For this purpose, conducting polymers are more versatile than conventional materials. The conductivity required can be chosen over a wide range, it can be oriented by processing techniques, and it can be switched on or off by means of an electric field. In addition, weight savings are

1. Representative conducting polymers

Material	Maximum conductivity, S/m	Structure	Available from:
Polyacetylene	1.5×10^7	Alternating single and double carbon-carbon bonds	Not commercially available
Polypyrrole	2.0×10^5	Five-membered rings containing nitrogen and alternating single and double carbon-carbon bonds	BASF Group, Ludwigshafen, Germany; Neste Oy, Espoo, Finland; Polaroid Corp., Cambridge, Mass.
Polyphenylene	1.0×10^5	Directly linked benzene rings	Not commercially available
Polyphenylene vinylene	1.0×10^5	A combination of polyacetylene and polyphenylene	Not commercially available
Polyphenylene sulfide	1.0×10^4	Benzene rings linked by suflur atoms	Hoechst-Celanese, Summit, N.J.; Philips 66, Bartlesville, Okla.
Polythiophene	1.0×10^4	Five-membered rings containing sulfur and alternating single and double carbon-carbon bonds	Allied-Signal Inc., Morristown, N.J.; BASF Group, Neste Oy
Polyaniline	1.0×10^3	Benzene rings linked by nitrogen atoms	Allied-Signal; Americhem Inc., Cuyahoga Falls, Ohio; Hexcel Corp., Dublin, Calif.; Lockheed Corp., Calabasas, Calif.; Neste Oy; Zipperling Kessler & Co., Ahrensburg, Germany

gained from the use of a polymer rather than a metallic conductor.

Last, but not least, both the Electric Power Research Institute of Palo Alto, Calif., and the U.S. Department of Energy have sponsored assessments of the likely usefulness of conducting polymers for power equipment, as well as what R&D would be necessary to bring the materials up to a competitive level with conventional materials.

POWER PROMISE. Several possible uses in the electric power industry involve the substitution of a conductive polymer for carbon black or other conductive fillers. Such products are used to dissipate static charges and to form electromagnetic shielding materials. The most promising applications to emerge from the Energy Department study were as a coating of the dielectric film in capacitors, which would short-circuit voids between films and inhibit partial discharges; as a surface coating to dissipate charge over the insulator surface of high-voltage bushings, thereby reducing flashover, a major cause of failure; and as a bulk resin (blended with a conventional resin such as epoxy) for the manufacture of bushings to control internal electric field distribution.

It should be noted that the applications for the electric power industry represent the most difficult challenge for conducting polymers in terms of reliability, performance, and cost.

TO PROBE FURTHER. The status of this developmental area was addressed by the authors in their paper "Conducting Polymers" at the IEEE's 1991 20th Electrical and Electronics Insulation Conference, Boston, Oct. 7-10, IEEE Publication No. 91CH2991-8.

Material and applications are discussed in "Electrically conductive polymers," by John R. Reynolds, *Chemtech*, Vol. 18, 1988, pp. 440-47.

An update of research efforts in the field is presented in the article "Conducting Polymers," M. G. Kanatzidis, *Chemical and Engineering News*, Dec. 3, 1990, pp. 36-54.

Power utility applications are emphasized in "The Promise of Conducting Polymers," Taylor Moore (background information by Seymour Alpert), *EPRI Journal*, July/August 1991, No. 5, pp. 4-13.

Research status and potential applications were addressed in "Conductive polymers give researchers a big jolt," by Tim Studt, *R&D Magazine*, October 1991, pp. 94-96.

ABOUT THE AUTHORS. Karl F. (Eric) Schoch (M) is a Fellow Scientist at the Westinghouse Science and Technology Center in Pittsburgh, specializing in conducting polymers' properties and applications. He holds four patents, with five more pending, and has published over 20 technical papers.

Howard E. Saunders (SM) works at the same center, as manager of polymer technology. He has published over 30 technical papers and holds 13 U.S. patents, with several more pending. ◆

2. Representative applications of conducting polymers

Commercial products	[illegible]
Batteries—primary	BASF-Varta, joint effort of BASF Group, Ludwigshafen, and Varta AG, Bad Homburg, Germany Bridgestone-Seiko, joint effort of Bridgestone Corp. and Seiko Corp., both of Tokyo
Biomedical devices	Medtronic Inc., Minneapolis 3M, St. Paul, Minn.
Electrolytic capacitors	Matsushita Electric Industrial Corp., Kadoma City, Japah
Fabrics	Milliken & Co., Spartanburgh, S.C.
Electric heat-tracing cables, leak-sensing cables, overcurrent protectors	Raychem Corp., Menlo Park, Calif.
Shelf-life detectors	Allied-Signal Inc., Morristown, N.J.
Near commercialization	
Coatings	Los Alamos National Laboratory, New Mexico, with the NASA Research Laboratory at the Kennedy Space Center, Florida Products Research and Chemical Corp., Woodland Hills, Calif. 3M
Clothing	Milliken
Fibers	Neste Oy, Kulloo, Finland Northwestern University, Evanston, Ill. Ohio State University, Columbus Uniax, Santa Barbara, Calif.
Field-effect transistors	Cambridge University, England Centre Nationale de la Recherche Scientifique, Paris, France Linköping University, Sweden Mitsubishi Electric Corp., Tokyo Westinghouse Electric Corp., Pittsburgh
Gas separation, storage, and controlled release	University of California, Los Angeles
Chemical, biochemical, and biological sensors	GTE Corp., Stamford, Conn. Harwell Laboratories, Cambridge, UK Honeywell Inc., Minneapolis, Minn. Allied-Signal, 3M
Smart skins	General Dynamics Corp., Falls Church, Va. Lockheed Corp., Calabasas, Calif.
Smart windows	General Motors Corp., Detroit, Mich. Gentex Corp., Zeeland, Mich. PPG Industries Inc., Pittsburgh Toyota Motor Corp., Toyota City, Japan GTE
Solar cells	Phototherm Inc., Athol, Mass.
Five to 10 years from commercialization	
Secondary batteries, electric vehicles	ABB (Asea Brown Boveri Ltd.), Baden, Switzerland Delco Electronics Corp., Kokoma, Ind. Hydro-Quebec, Montreal, Canada Sandia National Laboratories, Albuquerque, N.M. W.R. Grace & Co., New York City Yuasa Battery Co., Osaka, Japan 3M, Westinghouse
Electric equipment	Champlain Cable Corp., Winooski, Vt. Electric Power Research Institute, Palo Alto, Calif. U.S. Department of Energy, Washington, D.C. ABB, Allied-Signal, Westinghouse
Microactuators	Allied-Signal
Microelectronics, Schottky barriers, memory devices	IBM Corp.
Optical switches	Massachusetts Institute of Technology, Cambridge IBM, Uniax

EEs' tools & toys

Opting for updates in optical engineering

Two new biweeklies covering the field of optical engineering are designed to provide engineers and scientists with the latest technical literature in this domain. They are the result of a joint venture between the International Society for Optical Engineering (SPIE) and Engineering Information Inc. (EI) that allows EI to cull articles from SPIE's journals and make them available in print and on diskette. The venture also permits EI to transmit articles published in any SPIE journal by facsimile or via Internet within an hour of receipt of an order.

One publication, titled *EI/SPIE Page One*, is a biweekly listing of the tables of contents of some 100 optics journals worldwide, plus all conference proceedings from SPIE, all optical-related proceedings from the IEEE, including articles in *IEEE Spectrum*, and other sources.

The other publication, *EI/SPIE Critical Papers*, will be introduced in July as a series of biweekly newsletters. The series will contain abstracts of articles in five technical areas: sensors, optical-fiber networks and telecommunications, image processing, spectroscopic techniques, and optoelectric materials and devices. Each issue will contain about 75 abstracts.

In either print or diskette form, each biweekly is priced annually at US $140 for SPIE members and $175 for nonmembers. The diskette version allows keyword search by journal, article, title, and author. *Contact: Colby Kelly, Engineering Information Inc., 345 East 47th St., New York, N.Y. 10017; 212-705-7635; or* **circle 101.**

COMPUTERS

Turning data into graphics

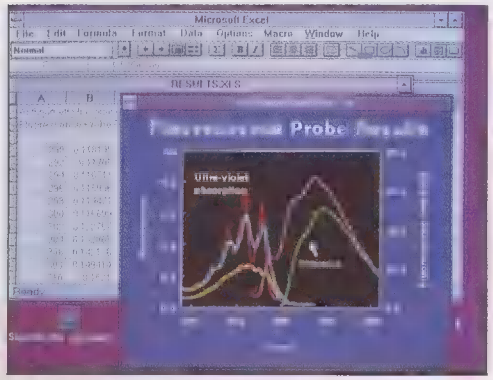
A new Windows version of a graphics presentation software package meant for scientists and technicians enables them to turn data from their IBM PC or compatible into reports, charts, graphs, and slide presentations.

The software, SlideWrite Plus for Windows, can plot up to 20 data series and up to 32 767 points per series in a single graph, giving a maximum of 655 340 points.

The new version is fully compatible with other major Windows applications and can also work with programs like Microsoft Excel and WordPerfect for Windows.

The software requires Microsoft Windows 3.0 or later version, in addition to a 80286 or higher microprocessor, a hard disk, 2M-byte RAM, a mouse, and a supported graphics card.

The cost is US $445. *Contact: Advanced Graphics Software Inc., 5825 Avenida Encinas, Suite 105, Carlsbad, Calif. 92008; 619-931-1919; fax, 619-931-9313; or* **circle 102.**



SlideWrite Plus for Windows is being used to graph absorption data saved in an Excel spreadsheet from Microsoft Corp.

CATALOGS

Computer power protection

Want to get a quick education in power problems and solutions? Need to check out newly available power products? A new 40-page catalog from Best Power Technology Inc. contains information on diagnosing and correcting power aberrations in three sections: "How to Solve Power Problems," "Choosing the Level of Protection That's Right for You," and "How to Buy Power Backup." Each section is accompanied by photographs, diagrams, and tables.

Some products showcased in the catalog include standby and uninterruptible power systems, power line conditioners, and multistage surge suppressors.

The catalog is free. *Contact: Best Power Technology Inc., Box 280, Necedah, Wis. 54646; 800-356-5794 (United States and Canada); 608-565-7200 (Wisconsin); fax, 608-565-2929; or* **circle 103.**

Export expertise

Designers of products slated for customers outside the United States can make use of a new catalog that aids in designing primary power circuits with international products. It also identifies vendors whose components comply with international standards.

The 224-page *Export Designer's Reference & Catalog No. 7* provides world plug and socket patterns and gives cross references to the countries where they are used.

Highlighted in the catalog's introduction are discussions on how to design a product for both North American and overseas markets, how to adapt existing products for export, and how to set up an export preparation area to test products before exportation.

Product sections speed up the selection process by offering first a review of the international safety issues and regulations for every electrical and electronic component. Also, decision trees and component selection charts provide details in selecting correctly rated international cordsets, connectors, and so on.

The catalog is free. *Contact: Panel Components Corp., 1360 North Dutton Ave., Santa Rosa, Calif. 95406; 800-662-2290 (United States and Canada) and 707-523-0600 (elsewhere); or* **circle 104.**

EDUCATION

Learning from industry

Scholars can learn more about the hows and whys of obtaining industry support in *Get Funded! A Practical Guide for Scholars Seeking Research Support from Business.*

The book, written by Dorin Schumacher, describes the corporate research environment and spells out ways in which scholars can interest a business in their research. Sections include strategies for success, programmatic approaches, and ethical perspectives on the university/industry connection. To improve such a partnership, the author emphasizes the need for researchers to take a personal approach when working with industry.

According to Schumacher, many researchers report having learned much of value from their collaboration with industrial contacts. They are able to keep in touch with the "real world," which benefits their teaching, and they have access to advanced equipment provided by corporate partners that might otherwise not be available. *Contact: Purdue University, 1132 Engineering Administration Building, West Lafayette, Ind. 47907-1132; 312-494-2096; fax, 317-494-0401; or* **circle 105.**

COORDINATOR: George Likourezos
CONSULTANT: Paul A.T. Wolfgang, Boeing Defense & Space Group

Program notes

Operating environments change for the better

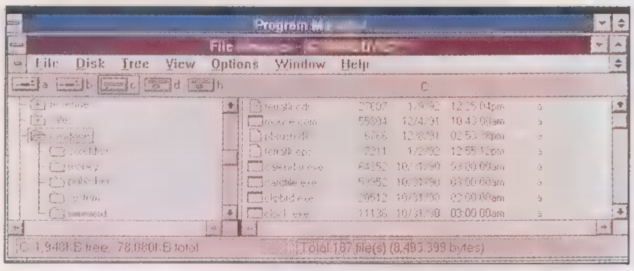
John R. Hines

Last January, *IEEE Spectrum* reported that the main weapons in the battle for software supremacy in personal computers would be revisions of OS/2 and Windows operating environments, both of which were scheduled (or, in the case of OS/2 2.0, rescheduled) for a spring debut. In April, along with the jonquils, the revised operating systems emerged, with Windows 3.1 blooming about a week ahead of OS/2 2.0.

Clearer Windows?

After having worked with it for a while, many users of Windows 3.0 noted five drawbacks:

- Unpredictable malfunctions that crashed applications and Windows itself, resulting in the dreaded Unrecoverable Application Error (UAE) message.
- No support for 32-bit applications.
- No true multitasking.
- Different fonts used for the printer and monitor so that What You See Is Not Exactly What You Get (WYSINEWIG?).
- A file manager almost as awkward to use as a DOS command line.



Unlike previous versions, Windows 3.1's file manager has a split-window display. On the left side of the window, a directory is selected (boxed); on the right, the directory's contents are listed in detail. The file manager also lets users look at directories of several drives in the same window.

Windows 3.1 is significantly different from 3.0: it is faster, more colorful, and equipped with more features. Unfortunately, many applications that ran under Windows 3.0 require patches to run under 3.1 or do not run at all. For example, a batch file used at Honeywell Inc.'s MicroSwitch Division to switch users from ■ Novell network to a transmission control protocol/internet protocol (TCP/IP) network and back again ran fine under Windows 3.0, but stopped working after 3.1 was installed. The problem was that before rebooting, unless a flush command was issued, the 3.1 version of SmartDrive would not copy new boot files for the desired protocol to the hard drive.

The attempt by Windows 3.1's designers to minimize UAEs was less than ■ complete success. Under Windows 3.0, a UAE typically threw a user out of Windows into DOS. Under Windows 3.1, pressing the ALT, CTRL, and DEL keys at the same time is supposed to kill an operationally flawed application without defenestrating the user. However, while evaluating 3.1, several complete system lockups occurred that could not be corrected by ALT/CTRL/DEL; in each case, rebooting was required.

The 32-bit Application Program Interface (API) for Windows 3.1 is less robust than the 16-bit API. It contains only a subset of the 16-bit toolkit. Since this makes *direct* conversions to 32 bits impossible, it will take time and effort to convert 16-bit applications to 32 bits. However, it should not take any more time to generate a new 32-bit application than to generate ■ new 16-bit one.

And users who want true multitasking in Windows still have to wait—for Windows NT, scheduled to make its debut later this year, or for possible future versions of Windows for DOS-based systems.

The good news is that the font technology in Windows 3.1 is an unqualified success. Microsoft purchased the basic technology, called TrueType, from Apple Computer Inc. Apple uses TrueType in System 7.0, the new Macintosh operating environment, so it should be easier to authentically display a document created on one type of system on the other. But for Windows-only users, the big advantage of TrueType is its speed. For example, with TrueType, Windows 3.1 can print Ami' Professional documents in about two-thirds the time of Windows 3.0.

To display type, Windows 3.1's graphics display interface (GDI) first calls a TrueType file of algorithms describing scalable outlines for the desired font. The TrueType rasterizer does more than convert a character's outline to the bitmap needed for monitor display or printer output—its high-level algorithms also provide hints on how to systematically distort a scaled outline to yield a better-looking bitmap for the target display device. Using a common, scalable typefont file for any display device provides visual consistency (WYSIWYG) while the hints in the algorithms make the difference between ragged and smooth characters.

Windows' file manager is indeed much easier to use; a split screen shows icons on the left and text on the right [see figure]. It is also much faster, especially when handling large directory trees. Much of the functionality previously seen in file managers created by third-party software vendors has been incorporated into Windows 3.1.

Should a professional group switch to 3.1 now as its main working environment? The answer depends on the applications that they will use. Applications like Excel 4.0 and Word for Windows run faster and look better under 3.1, thanks to TrueType, and the new file manager simplifies file manipulations. Many older applications, though, will not run under 3.1. If in doubt about whether an important application will run reliably under 3.1, wait until the vendor upgrades the application to Windows 3.1 and Microsoft makes patches for 3.1's bugs available. *For more on Windows 3.1, contact: Microsoft Corp., One Microsoft Way, Redmond, Wash. 98052-6399; 800-426-9400; or* **circle no. 106.** *For more on TrueType, contact Apple Computer Inc., 20525 Mariani Ave., Cupertino, Calif. 95014; 408-996-1010; or* **circle no. 107.**

OS/2 2.0: a comfortable ride

Compared to Windows, using OS/2 2.0 is like driving a sedan rather than a sports car: the ride is much smoother, but the vehicle is less exciting and glamorous.

The user interface to OS/2 2.0 is the Workplace Shell and, while it does not look a lot like Windows, it is logical and easy to use. If ■ user cannot accustom him- or herself to the Workplace Shell, ■ Windows look-and-feel interface is available to replace it.

There are few unhappy surprises from OS/2 2.0. Everything that worked in Windows 3.0 works in OS/2 2.0, as well as DOS programs written for OS/2 1.x. Further, since OS/2 2.0 is ■ 32-bit operating system, running 32-bit applications is no problem. As the OS/2 2.0 Application Programming Interface (API) is ■ superset of the OS/2 1.x API, converting old OS/2 1.x applications to 2.0 applications is straightforward.

True multitasking is the feature that differentiates OS/2 2.0 from Windows 3.1; it simplifies the elimination of UAEs. Under OS/2, many tasks can run at the same time, whether interrelated or not. Since it was designed for multiple, simultaneously running tasks, OS/2 is equipped to terminate a flawed task (UAE) without kicking the user out of the operating environment or locking up the computer.

In an important sense, multitasking actu-

(Continued on p. 61)

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Practical Unix Security. *Garfinkel, Simson*, and *Spafford, Gene*, O'Reilly & Associates, Sebastopol, Calif., 1992, 483 pp., $29.95.

Turbo C++ DiskTutor, 2nd edition. *Voss, Greg*, and *Chui, Paul*, Osborne/McGraw-Hill, Berkeley, Calif., 1991, 510 pp., $39.95.

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Running MS-DOS QBasic. *Halvorson, Michael*, and *Rygmyr, David*, Microsoft Press, Redmond, Wash., 1991, 596 pp., $22.95.

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Morse Code—The Essential Language. *Carron, L. Peter, Jr.,* American Radio Relay League, Newington, Conn., 1991, 300 pp., $6.

Linking LANs—A Micro Manager's Guide. *Schatt, Stan,* Windcrest, Blue Ridge Summit, Pa., 1991, 299 pp., $22.95.

Microsoft Mouse Programmer's Reference—2nd edition. *Microsoft,* Microsoft Press, Redmond, Wash., 1991, 328 pp., $34.95.

Neural Networks. *Mammone, Richard J.,* and *Zeevi, Yehoshua,* Academic Press, San Diego, Calif., 1991, 355 pp., $39.95.

DAT. *Horn, Delton T.,* TAB Books, Blue Ridge Summit, Pa., 1991, 254 pp., $12.95.

Advanced Microprocessors. *Tabak, Daniel,* McGraw-Hill, New York, 1991, 534 pp., $49.95.

Computer-Operated Systems Control. *Mahmoud, Magdi S.,* Marcel Dekker, New York, 1991, 680 pp., $150.

Troubleshooting Analog Circuits. *Pease, Robert A.,* Butterworth-Heinemann, Stoneham, Mass., 1991, 217 pp., $32.95.

Client-Server-Programming with OS/2—Extended edition. *Orfali, Robert,* and *Harkey, Dan,* Van Nostrand Reinhold, New York, 1991, 1088 pp., $39.95.

Total Manufacturing Management: Production Organization for the 1990s. *Merli, Giorgio,* Productivity Press, Cambridge, Mass., 1991, 348 pp., $39.95.

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Program notes

(Continued from p. 58)

ally adds functionality to OS/2. For example, running two DOS programs under OS/2 2.0 is simple and straightforward, whereas running the same two programs under Windows 3.1 would be awkward or impossible.

OS/2 2.0's font manager generates a common font for monitor and printer, much like TrueType. It seems slower than TrueType, but is quite usable and generates documents that look good.

Probably the weakest feature in OS/2 2.0 is its file manager, which does not improve noticeably on Windows 3.0's file manager.

Before jumping into OS/2, however, look at the DOS utilities your group is using. If they cannot be replaced or eliminated, switching to OS/2 2.0 might prove expensive or unwise at present. For example, if disk compression software has been in use for some time, new hard disks will be needed before you can switch to OS/2, for which no disk compression software is yet available. Programs designed specifically for Windows-3.1 will not run under OS/2 2.0. *Contact: IBM Corp.'s HelpCenter between 9:00 a.m. and 5:00 p.m., local time; 800-772-2227; or* **circle no. 108.**

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John R. Hines (M) is silicon sensors engineer at Honeywell Inc.'s MicroSwitch Division, Richardson, Texas.

COORDINATOR: Richard Comerford
CONSULTANTS: Stuart Feldman, Computer Systems Research, Bellcore, and John Kellum, Intergraph Advanced Processor Division

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the university. A Ph.D. is required. A dedicated staff is available to assist faculty in the preparation of research proposals and the identification of potential funding sources. Tenure track appointments will be limited to U.S. citizens and resident aliens. Rank and salary will be commensurate with qualifications and experience. Positions will remain open until acceptable candidates [redacted] found. Please send letter of application with vitae and three references to: Professor James E. Baker, Head, School of Electrical and Computer Engineering, 202 Engineering South, Stillwater, OK 74078-0545.

Engineer I (Electrical). B.S. Degree in Electrical Engineering. Working knowledge of high reliability soldering and design, construction and repair of high reliability circuits and Meteorological Sounding techniques. Travel to Artic region for atmospheric tests. Design, construct and repair of compact battery operated electronics for remote use in atmospheric physics research using oscilloscopes, multimeters, AC/DC power supplies, pulse generator, function generator, drill machines, drill press, heat guns, shearing machines, computers, RF receivers and modems. Launch balloons for atmospheric research. 40 hr. wk. Salary: $22,008 per year. Apply by resume to Wyoming Department of Labor, Laramie Job Service Center, 112 South 5th Street, Laramie, Wyoming 82070. Refer to Order Number WY0282172, No later than June 30, 1992.

Two Faculty Positions—Gunma University—Department of Electrical and Electronic Engineering. The Department of Electrical and Electronic Engineering is seeking applications to fill two positions at the assistant professor level in the areas of electronic materials and the related field to LSI design and fabrication. The applicants are expected to teach at the undergraduate levels, and graduate levels in Japanese language and to develop extensive research project. The applicants for the first position should have deep interest in the area of electronic materials, for example, intelligent thin film, materials of superconductor and its development and its physical properties. The second position should have interest in the area of the related field to LSI, for example its circuit design, software for the circuit design and its fabrication. Candidates for the positions must have [redacted] doctor of engineering and an excellent research record. A curriculum vitae, a brief description of proposed research, a publication list, and at least two recommendation letters should be sent by August 31, 1992, to Professor Minoru Sugawara, Department of Electrical and Electronic Engineering, Gunma University, Kiryu, Gunma, Japan.

Dean—Institute of Technology, University of Minnesota, Twin Cities. The University of Minnesota, Twin Cities, invites applications and nominations for the position of Dean of the Institute of Technology. The Institute consists of the departments of mathematics, physical sciences and engineering of one of the largest land-grant universities in the nation. The Dean reports to the Vice Provost for Arts, Sciences and Engineering. The successful candidate must have: (1) Ph.D. degree or requisite terminal degree, (2) record of teaching and research commensurate with a tenured professor in the Institute, (3) strong commitment to academic excellence, (4) demonstrated ability to articulate the Institute's mission and work effectively with university community and external constituencies, (5) administrative experience, and (6) demonstrated commitment to equal opportunity and affirmative action. Applications should include a letter expressing interest, a vita, and the names, addresses and phone numbers of three references. Nominations are also encouraged. Applications or nominations must be postmarked (or Fax-dated) by July 1, 1992. Send to: Dr. H. Ted Davis, University of Minnesota, 421 Washington Ave, S.E., Minneapolis, MN 55455, Fax: 612-626-7246. The University of Minnesota is committed to the policy that all persons shall have access to its programs, facilities, and employment without regard to race, color, creed, religion, national origin, sex, age, marital status, disability, public assistance status, veteran status, or sexual orientation.

The University of Hong Kong. Honda Chair in Electric Vehicles, Department of Electrical and Electronic Engineering (Ref. 91/92-93). Applications are invited for a professorship in the Department of Electrical and Electronic Engineering. This post is partially sponsored by Honda R&D Co. Ltd. Japan, and will be known as Honda Chair in Electric Vehicles. The appointment will be made initially on [redacted] three-year fixed term contract with a possibility of renewal. Candidates should have [redacted] distinguished record in research and scholarly publications in electric vehicles, evidence of leadership in promoting international research co-operation, and strong commitment to teaching and curriculum development in electrical energy systems engineering. Candidates must hold doctorate degrees and fellowships of internationally recognized leading professional institutions. The University reserves the right not to fill the Chair or to fill the Chair by invitation or to make an appointment at [redacted] lower level. Annual salary [non-superannuable but attracting 25% (taxable) terminal gratuity] will be within the professional range, of which the minimum is HK$685,620 and the average is HK$848,040 (approx. US$1=HK$7.70 as of April 10, 1992). At current rates, salaries tax will not exceed 15% of gross income. Housing at a charge of 7.5% of salary, children's education allowances, leave and medical benefits [redacted] provided. Further particulars and application forms may be obtained from Appointments (40556), Association of Commonwealth Universities, 36 Gordon Square, London WC1H, OPF, UK; or from the Appointments Unit, Registry, The University of Hong Kong, Hong Kong (Fax (852) 5592058; E-mail:APPTUNIT@HKUVM1.HKU.HK). Closes: 10 June 1992.

Faculty Position in Medical Imaging—The Departments of Biomedical Engineering (BME) and Radiology at the University of North Carolina invite applications for [redacted] tenure-track faculty position at the Assistant/Associate Professor level. Candidates should have [redacted] Ph.D. degree in engineering, physics, applied mathematics, or a related area and be experienced in medical imaging research. Preference will be given to candidates who specialize in the areas of MRI and/or digital x-ray. The successful candidate should have experience or demonstrated potential in securing external research funding. He/She is expected to participate in teaching in the graduate program of BME and to advise students in dissertation research. He/She will join another faculty member in BME and a diverse group of scientists from the Departments of Computer Science, Radiology, and Radiation Oncology who are actively pursuing different areas of medical imaging research. Send resumes to Dr. Carol L. Lucas, Professor and Chair, Department of Biomedical Engineering, CB #7575, 152 MacNider Hall, The University of North Carolina, Chapel Hill, NC 27599. Applications will be accepted until August 1, 1992, or until position is filled. The University of North Carolina is [redacted] Equal Opportunity/Affirmative Action Employer.

The Department of Electrical Engineering, University of British Columbia invites applications for [redacted] tenure-track Assistant Professor appointment in Computer Engineering. Software engineering, including real-time applications, is of primary interest, although applications in other areas of computer engineering [redacted] encouraged. A Ph.D. is required. Industrial and/or teaching experience would be useful. The successful applicant would be expected to pursue research vigorously, and to teach at the graduate and undergraduate levels. Collaboration with the Department of Computer Science is facilitated through the Centre for Integrated Computer Systems Research. Salary is commensurate with qualifications and experience. Start-up funding is available for purchase of equipment and support of graduate student research assistants. The position is available from July 1, 1992. Priority will be given to applications received on or before July 31,1992. To apply, send curriculum vitae, reprints of published papers, and names of at least three references, and state eligibility for employment in Canada to: Dr. R.W. Donaldson, Head, Department of Electrical Engineering, The University of British Columbia, 2356 Main Mall, Vancouver, B.C. Canada V6T 1Z4. The University of British Columbia encourages qualified women and minority applicants. In accordance with Canadian Immigration requirements, priority will be given to Canadian citizens and permanent residents of Canada.

Hong Kong Polytechnic—Department of Electrical Engineering. Principal Lecturer in Fibre Optics or Control & Automation (HK$457,140 p.a.—HK$589,740 p.a.). Candidates should have (a) a good honours degree or equivalent professional qualification and preferably a doctoral degree or [redacted] advanced specialist qualification; (b) extensive experience in areas such as teaching, research, consultancy, curriculum development, industrial/commercial/public service employment; and (c) proven record of successful leadership in the subject area. Senior Lecturer in Fibre Optics or Control & Automation (HK$385,020 p.a. - HK$511,860 p.a.). Candidates should have (a) a good honours degree or equivalent professional qualification and preferably an advanced specialist qualification; (b) substantial professional/teaching/research experience, and (c) potential for academic leadership. (Note: US$1 = HK$7.745 as of 27.4.92). Conditions of Service—Initial appointments will be on [redacted] fixed-term contract of two years at the end of which a gratuity equal to 25% of basic salary earned over the whole contract period will be payable. Continuation thereafter is subject to mutual agreement. Other benefits include leave, medical & dental schemes, children's education allowance and subsidized housing. Application—Applications including curriculum vitae and names of three referees should be sent to the General Secretary, Hong Kong Polytechnic, Hung Hom, Kowloon, Hong Kong before June 22, 1992 [fax (852) 3642166]. Further information is available from the same office.

The Swiss Federal Institute of Technology Zurich (ETHZ) invites applications for a Faculty Position in Microelectronic Systems. The new professor has to contribute to research and teaching in the [redacted] of algorithms, design and realization of complex analog/digital integrated circuits and systems. Candidates should hold [redacted] university degree and have several years of experience in research and/or development in the above-mentioned field. They should be able to establish and carry out advanced research programs, teach courses at both the graduate and undergraduate levels, and interact favorably with industry and other university laboratories. Please apply with a curriculum vitae, a short description of research interests and a list of publications, by June 30, 1992, to the President of ETHZ, Prof. Dr. J. Nuesch, ETH Zentrum, CH-8092 Zurich. The ETHZ specifically encourages female candidates to apply with a view towards increasing the proportion of female professors.

The Swiss Federal Institute of Technology Zurich (ETHZ) is looking for an Assistant Professor in Electronics. The new professor has to contribute to research and teaching in the [redacted] of design of high speed analog/digital integrated circuits. Candidates should have [redacted] university degree as well [redacted] experience in research and/or development in the above-mentioned field. They must be able to carry out advanced research work, teach courses at the graduate level, and interact favorably with industry and other university laboratories. The post of an assistant professor has been established to further the career of younger scientists. It is available for three years in the first instance, and renewable for another three years. Please apply with a curriculum vitae, a short description of research interests and a list of publications, by June 30, 1992, to the President of ETHZ, Prof. Dr. J. Nuesch, ETH Zentrum, CH-8092 Zurich. The ETHZ specifically encourages female candidates to apply with [redacted] view towards increasing the proportion of female professors.

Research Opportunities in Microelectronics and VLSI Design. The Department of Electrical Engineering at Colorado State University has an opening for a highly-qualified Ph.D. candidate or Research Associate in microelectronics and VLSI design starting August 20, 1992. Current research activities include self-testing and self- repairing memory architectures for future 256 Mb—1 Gb memory chips, fault-tolerant massive parallel processing architectures for DSP and general-purpose computing, neural chip architectures, modeling and design of MCM systems, and CAD techniques for VLSI de-

sign. The Department of Electrical Engineering has state-of-the-art VLSI design and processing labs equipped with HP700 and 400 series workstations and Mentor Graphics EDA tools. High technology corporations such as Hewlett-Packard and NCR Microelectronics have major operations in the area and provide support for the microelectronics and VLSI design programs. Located at the foothills of the Rocky Mountains, 60 miles north of Denver, CSU and the City of Fort Collins offer a beautiful environment and many outdoor activities. A successful Ph.D. candidate will have a M.S. in Electrical Engineering or related areas and will receive a monthly stipend and paid tuition. A Research Associate candidate will have a Ph.D. or M.S. with substantial research experience in the related areas. Salary will commensurate for the position and related experience. Reply to Dr. Tom Chen, Department of Electrical Engineering, Colorado State University, Fort Collins, CO 80523. Telephone: (303) 491-6574. FAX: (303) 491-2249. Colorado State is an EOE/AA employer. E.O. Office: Room 21 Spruce Hall.

Princeton University: the Department of Electrical Engineering invites applications for a full time tenure-track faculty position in the area of optics and advanced photonic materials, devices or systems. Materials, devices or architectures work should concentrate on their application to ultra high bandwidth or high density photonic systems. Examples include semiconductor lasers, ultrahigh bandwidth integrated circuits, III-V and II-VI photonic device fabrication and characterization, optoelectronic integrated circuits, integrated optics, optical/materials interactions, photorefractive and nonlinear optical materials and devices, and optical architectures including computers, neural nets, signal processors, etc. Candidates should have a desire for working in ■ group environment on collaborative projects with new scientific objectives and content. Please send ■ complete resume, ■ description of research and teaching interests, and names of three references to Professor Stuart Schwartz, Chair, Dept. of EE, Princeton University, Princeton, NJ 08540-5263. Princeton University is ■■ equal opportunity/affirmative action employer.

The Australian National University—Research School of Physical Sciences and Engineering. Postdoctoral Fellowships (Academic Level A)/Research Fellowships (Academic Level B). These fellowships are intended for those who have recently completed, or expect by 31 December 1992 to complete, requirements for ■ PhD degree or equivalent qualification. Successful appointees will be expected to take up their positions by the middle of 1993. Appointments will be for two years only and may be in any field of research of interest to the School. The School consists of ■ General Physics Division (applied mathematics, atomic and molecular physics, laser physics, optical sciences, plasma physics), an Engineering Division (computer sciences, electronic materials engineering, systems engineering), and departments of Nuclear Physics and Theoretical Physics. Intending applicants should obtain application material from the School Secretary, Research School of Physical Sciences and Engineering on Fax 61 6 2491884 or Emailsec050@rsphyl.anu.edu.au before making an application. Enquiries should also be directed to the School Secretary, Telephone 61 6 293872 or 295195. Closing Date: 30 July 1992. Ref: PSE 28.4.1. Salary: Postdoctoral Fellow A$30,340-A$37,618 p.a.; Research Fellow A$39,463-A$47,150 p.a. Applications addressing the selection criteria should be submitted in duplicate to the Secretary, The Australian National University, GPO Box 4, Canberra ACT 2601, Australia, quoting reference number and including curriculum vitae, list of publications and names of at least three referees. The University is an Equal Opportunity Employer.

Government/Industry Positions Open

Design Engineer for firm in NE Ohio. To design the data acquisition series products for use with microcomputer systems. This includes: Designing hardware for these products including high speed and high precision (16-bit) Analog-to-Digital (A/D) and Digital-to-Analog (D/A) conversion circuits; flexible and reliable interface with various microcomputer systems; and design verification. Designing appropriate software for these products, including an Assembly language driver package that supports various high level programming languages; ■ testing program for production and maintenance; and utility programs for digital signal processing and data logging. Developing menu driven utility programs that have both English and Chinese language versions. Must have M.S. in Electrical Engineering. Academic program must have included one course each in the following areas: Analog-to-Digital Conversion, Fault Tolerance in Computers, Microcomputers, Microelectronics, Digital Signal Processing, Signal Detection and Estimation, Software Engineering, and Computer Algorithms. Must be conversant, as evidenced by academic letter(s) of reference and/or employer testimonial(s), with advanced laboratory instruments, in particular, the logic analyzer and the digital signal signature analyzer. Must be able to speak, read, and write Mandarin Chinese and use the Chinese Character Disk Operating System. Must have one year of experience in electrical engineering. Experience must have been in designing analog/digital circuits, including the interface with various computer systems and in testing. Experience may be gained before, during, or after degree. 40 hrs/wk, 8:00am-5:00pm, $36,575/yr. Must have proof of legal authority to work permanently in U.S. Send resume & course transcript in duplicate (no calls) to J. Davies, JO# 1269196, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, Ohio 43216.

Computer Engineer for development & mfg. firm in NE OH to design, implement & test computer hardware & software on Computed Tomography (CT) & Nuclear (NUC) Medicine Imaging Systems. The engr. will design 68000—based network & interface boards; implement SCSI, Ethernet, Centronix, Multibus II, RS232, RS485; develop diagnostic code for mfg. testing in C, 68000 & 8051 assembly language; implement embedded real-time operating system (OS), TCP/IP & device drivers. Must have BS in Elec. Engr. w/crsework in Multitasking OS Design, VLSI System Design, Computer Architecture & Org. Must have 1 yr. exp. in computer hardware design & software engrg. Require exp. w/programmable logic & gate array design; diagnostic coding for mfg.; implementation of embedded multitasking OS, SCSI, Ethernet, Multibus II & TCP/IP. Require C, 68000, 8051 assembly language. CT & NUC Med. product exp. may be gained before, during or after degree. 40 hrs/wk, 8am—5pm, Mon-Fri. $33,000/yr. Must have proof of legal authority to work permanently in U.S. Send resumes & transcript in duplicate (no call) to J. Davies JO# 1200858, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, OH 43216.

Software Engineer for research, development, & mfg. firm in NE Ohio to design, implement & maintain software for Nuclear Medicine Image Diagnostic system. The engineer will work on the software of real-time motion control for gamma camera & patient table, data acquisition, image processing & reconstruction, graphic user interfaced applications. It also involves computer interface, data communication, computer network, image database software. All works utilize C & Motorola 68000 Assembly computer languages under UNIX & DOS operating system & X window environment. Must have an M.S. in computer Science or Engineering with graduate level courses in Computer Algorithm, Graphics, Database Management & Operating System. Must have 1 year exp. in design, development & implement real-time motion control software. Experience in image processing & reconstruction, computer hardware & electrical engineering are required. 40hrs/wk, 8am-5pm, Mon-Fri: $36,213/yr. Must have proof of legal authority to work permanently in U.S. Send resume & courses transcript in duplicate (no calls) to S. Holton, JO#1200873, Ohio Bureau of Employment Services, PO Box 1618, Columbus, OH 43216.

Science Research Laboratory (SRL) has an immediate opening for an experienced, self-motivated Senior Research Scientist in its Alameda, CA facility. SRL is engaged in cutting edge R&D in discharge driven x-ray sources for sub-micron lithography, stable isotope enrichment in rotating, magnetized plasmas, fast plasma opening switches for multiterawatt pulsed power generators, high current imploding plasma z-pinches and advanced instruments for flash x-ray measurements. The prospective candidate must possess ■ Ph.D. in plasma physics or closely related discipline and have at least five years laboratory experience with pulsed power, gas/vacuum arc discharges and x-ray measurements. The successful candidate must complement efficient laboratory research skills with above average technical writing and oral presentation skills. SRL offers ■ competitive salary/benefits package, an excellent locale in the San Francisco Bay Area and outstanding potential for professional growth in ■ small business R&D environment. Please send a resume and names of at least three references to: SRL, 1150 Ballena Boulevard/Suite 100, Alameda, CA 94501.

Electrical Engineer wanted. Duties: Responsible for designing, developing and testing electrical distribution circuits carrying 4.8 KV and 13.2 KV voltage and substations in ■ major utility company's power grid to maximize reliability applying principles and techniques of electrical engineering; improving circuit design and infrastructure for poor performing circuits in a cost-effective manner; and reviewing and interpreting test results and making design recommendation to ensure power system security. Requirements: Master's in Electrical Engineering. Master's course work must include research in the area of power system stability analysis using C & Mathematica languages in a UNIX environment and IBM, Macintosh & DOS. Master's thesis must be oriented towards power system simulation and modelling, system voltage collapse investigation and analysis. Pay is $37,050 per yr. 40 hr/wk. Resumes to 7310 Woodward Ave., Rm 415, Detroit, MI 48202. Ref. #19492. Employer Paid Ad.

Engineer, Ultrasonic Systems Design. Will be responsible for development of novel piezoelectric transducers using conventional and composite materials for medical and NDT applications; writing technical reports and publishing papers; developing appropriate simulation (including direct time domain solutions using z-transforms) and instrumentation software in Fortran; industrial consulting and supervising personnel. Reqs. Ph.D. in Ultrasonic Systems Engineering and a demonstrated ability to design and implement practical acoustic devices. Must be familiar with measurements required to comply with current FDA standards for diagnostic transducer report filing. Must possess practical skills such as precision lapping and grinding, basic machining, thin film deposition and the knowledge to effect zero thickness bonds. Salary is $49,615 per year, 40 hours per week. Job Site/Interview: Milpitas, CA. Send this ad and resume to Job #DB 22856, P.O. 9560, Sacramento, CA 95823, no later than June 30th.

Electrical Engineer—To develop signaling products including fault tolerant, distributed, packet switched systems used throughout the switching product line. Involves analyzing the effects of core technology and network feature introduction on existing signaling products, developing system level integration tests, executing tests; and improving the quality of the signaling subsystem. Requires ■ PhD degree in Electrical Engineering with graduate coursework in the area of hardware design, software design, fault tolerant design, and distributed processing systems. PhD research related to system integration and system analysis using UNIX, C, SUN workstation is required. Experience may be gained before, during or after degree. Applicant must also have two years' experience in the job offered or two years ■■ ■ Research Associate in Electrical Engineering. 40 hours per week, (work schedule, 8:15 a.m. to 5:15 p.m.). Salary is $60,000.00 per year. Must have proof of legal authority to work permanently in the U.S. Send resume in duplicate (no calls) to: J. Davies, JO #1260379, Ohio Bureau of Employment Services, P.O. Box 1618, Columbus, OH 43216. EOE.

Electrical Engineer IV ($39,084.76-$53,470.00). Hiring Range: $39,084.76-$49,729.38. Graduation from an accredited college or university with a Bachelor's Degree in Electrical Engineering and six years of professional electrical engineering experience, including two years experience [redacted] a registered professional engineer; or an equivalent combination of training and experience. Deadline for inquiries: June 26, 1992. For further information and application materials, please contact: Linda Thomas, Personnel Department, City of El Paso, 2 Civic Center Plaza, El Paso, TX 79901-1196, phone (915) 541-4102. AA/EOE.

Electrical Engineering Technology. Tenure-track position available August 1992. Qualifications include M.S. or Ph.D. in electrical engineering, three years engineering experience and one or more years teaching experience. Professional Engineering registration is desirable. A commitment to teaching excellence and responsiveness to student needs are essential. Send letter of application, resume, at least three letters of reference and official transcripts to Office of Academic Affairs, EET Search, Western Kentucky University, 1526 Russellville Road, Bowling Green, KY 42101-3576. Application review begins June 15, 1992. Women and minorities encouraged to apply. Affirmative Action/Equal Opportunity Employer.

Process Development Engineer: Resp. for participating in thermal and CVD ("hot") processing, including identifying, designing, characterizing, and implementing new process technologies, equipment, and techniques, and transferring those items into routine production with sufficient documentation and support. Req. Ph.D. degree in Electrical Engineering. Also req. knowledge of Low Pressure Chemical Vapor Deposition (LPCVD) of doped and undoped polycrystalline/amorphous silicon, and silicon dioxide (high temperature CVD oxide, low-temperature oxide, and TEOS); of thermal oxidation processes for growing thin, low defect density gate oxides; of rapid thermal processing for VLSI applications; and of advanced device isolation techniques, such [redacted] LOCOS, poly buffered LOCOS, and shallow trench isolation. Salary: $55,000/yr. Job/intvw site: San Jose, CA. Send ad w/resume to Job #BLW9587, P.O. Box 9560, Sacramento, CA 95823-0560 no later than June 30, 1992. EOE.

Computer Architect. Define new instruction set architecture for software & hardware product architectural development; conduct high-level & detail-level performance simulation development & architectural definition; evaluate design tradeoffs for microprocessors, including benchmark & software and hardware component performance; develop performance evaluation tools. Ph.D. in Computer Engineering or Electrical Engineering or Computer Systems Engineering. Academic project/research background in instruction set architecture definition, evaluation, development & implementation, including processor-architecture tradeoffs, architect workbench design, application specific architecture design & architecture for high-performance microprocessor design, computer system design, memory architecture design, simulation program development for architectural evaluation, CMOS VLSI & logic design, compiler optimization techniques, computer architecture, software development, C, C++ & UNIX. $6,000/mo.; 40 hrs./wk. Place of employment and interview: Santa Clara, CA. If offered employment, must show legal right to work. Send this ad and your resume to: Job No. WS12679, P.O. Box 9560, Sacramento, CA 95823-0560 not later than June 30, 1992. The company is an equal opportunity employer and fully supports affirmative action practices.

Software Engineer/Technical Representative. Resp. for installation of systems hardware & software, incl. performing appropriate system tests & providing first-level hardware, diagnostic, & maintenance support for large systems software development company utilizing a robust Ada-based software engineering environment. Will also interact with customers to determine their computing needs, define measurable plans for implementation, provide presales support in the form of technical presentations & demonstrations, & provide ongoing consulting to ensure that goals & objectives are attained. Additional duties include providing installation implementation, including customer training & software conversions or re-hosting, allowing integration into existing customer networks. Specif., will provide consulting & support to local developers of large Ada systems software. Req. B.S. degree or equiv. in Elect. or Comp. Engineering & 4 yrs. exp. in the job offered or in software engineering. Also req. exp. in software design, code, test, and integration; in CASE tools and methodologies; in Ada language development; in providing field engineering support for hardware and software systems; and in project leadership/management for large software systems development. 40 hrs/wk. 8:00 a.m.-5:00 p.m. Salary: $4,400/mo. Job/intvw site: Friendswood, TX. Apply at the Texas Employment Commission, Houston, Texas, or send resume to the Texas Employment Commission, TEC Building, Austin, Texas 78778, J.O.# 6687535. Ad paid by An Equal Employment Opportunity Employer.

Instructors Wanted. Must have; telecommunications background, 5 years corporate education training, 7 years software development background, CASE knowledge Hatley/Pirbhai & Yourdon knowledge. Please be advised that this position is on an independent contractor basis. Send Resumes To: Tony Formica, Kenneth G. Moore and Associates, Inc., 875 Avenue of the Americas, New York, NY 10001.

Associate Product Manager to develop and implement marketing strategies for programmers and other external instrumentation relating to pacemakers and defibrillators. Responsibilities include: liaison activities and training of sales, field, and professional medical personnel; assistance with and coordination of manufacturing, distribution and inventory issues; and coordination of such company functions as research and development, quality assurance, manufacturing and finance. Education and experience requirements: B.S. in electrical engineering and M.B.A. minimum; at least one year experience in new product planning in pacemaking and defibrillator manufacturing fields. Prevailing working conditions. Training. Salary: $4,000 per month. Please reply to S. Springmeyer, [redacted] 1-238, Minnesota Department of Jobs and Training, 390 No. Robert Street, Room 124, St. Paul, MN 55101.

Engineer: Senior Process. Resp. for designg & developng an advanced submicron Bi-CMOS device & process. Knowldg of high speed, high performance devices & circuits, includng fabricatn & testng. Knowldg of Schottky diode & photodetector fabricatn suitable for monolithic integratn. Knowldg of high speed device simulatn; knowldg of developmnt & maintenance of thin film processes for both MOS & bipolar devices. Knowldg of wet chemical processng, photolithography, diffusion, oxidatn, ion implantatn, ion millng, optical & electron microscopy, & reliability testng. Knowldg of solid state physics & band theory. Jobsite: Santa Clara, CA. Ph.D. in E.E. or equiv. Entry level. Salary: $4768/mo. 40hrs/wk. Clip ad & submit w/resume to IEEE Spectrum Magazine, P.O. Box 6-2, 345 E. 47th St., New York, NY 10017 before 07-01-92.

Field Engineer. Design, develop and service Industrial Drive Systems including project engineering duties. Job requires: Masters degree in Electrical Engineering, four years of related experience, and international travel. 40hrs./wk., 8:00am-5:00pm; $48,000/yr. To apply: mail or hand carry resume w/copy of ad attached. To: VEC, Dept. 3008, 1202 Franklin Rd., S.W., Roanoke, VA 24002-0061. J.O. # VA1043246. The closing date is June 30, 1992. An Employer Paid Ad.

Orbit Advanced Technologies, Inc. is active in the areas of instrumentation for far-field and near-field antenna measurement systems, antenna tracking systems for communication and telemetry, and aircraft communication system upgrades. Our main office is in Horsham, Pennsylvania. Long range plans include opening an office in California. We are looking for candidates who have experience in the following related areas and possess at minimum, a B.S. in Engineering or related field. Product Line Manager (tracking and telemetry)—Candidate should have the ability to manage and market existing and emerging product lines. Project Manager (tracking and telemetry)—Candidate should have experience in leading multi-million dollar projects. Marketing and proposal preparation skills are preferred. Marketing Manager-Experience in antenna measurement and/or tracking is required. Sales Manager—Experience in antenna measurement and/or tracking is required. Software Programmer (automatic test equipment) -Four years experience in a scientific/engineering environment is required. Experience with Fortran 77, C++, Object Orientation, and Microsoft Windows 3.0. Experience in IEEE488, Real Time, and Graphics is desired. U.S. citizenship is required. Send resumes to: Orbit Advanced Technologies, Inc., Attn: Personnel Dept., 905 Sheehy Drive, Building G, Horsham, PA 19044. Orbit Advanced Technologies is an equal opportunity employer.

Research and Development Engineer, 40hrs/wk., 9:00am -5:00pm, M-F, $34,580/year. Hardware design and software development for new Intel 80386, 80486 laptop computer and notebook computer, pen-based notebook computer with artificial intelligence features and neural network-based computing system. Projects include the design of graphics cards and Token Ring Ethernet network card. Signal processing, data communications and foreign language character recognition. Existing products testing, troubleshooting and modifications. Tools: Logical Analyzer; Digital Storage Oscilloscope; Future-Net5; Orcad; Spice; PADS-PCB; C and Assembly programming languages. Master of Science in Electrical Engineering as well as one year experience [redacted] Research and Development Engineer or Graduate Assistant required. Previous experience must include: signal processing; debugging of PC mother boards and add-on cards; programming in C and Assembly. Must speak, read, and write Mandarin Chinese. Graduate coursework must include: Neural network-based computing systems; High-Frequency Transmission & Radiation; Design and Analysis of Integrated Circuits. Must have proof of legal authority to work permanently in the United States. Send two copies of your resume to: Illinois Department of Employment Security, 401 South State Street—3 South, Chicago, Illinois 60605, Attention: J. Aschenbrenner, Reference #V-IL-4982-A, no calls, An Employer Paid Ad.

Government/Industry Position Wanted

Math M.S. 25 yrs R&D, pubs guid waves sys seeks 2-4 mo pos Num Meth-coding Fortran/Rocky Mtn Basic have PC486 (303)494-8405.

Electrical Engineer seeking entry level hardware design position. BSEE from Rensselaer includes co-op experience and extensive theoretical and practical background in EE hardware concentration. Computer programming and CAD skills also. Reply to Spectrum Magazine, Box #6-1, 345 E. 47th St., New York, NY 10017.

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Presidential candidates should foster high tech

Concerned about the survival of "our high-tech workforce [and] . . . about the United States' ability to function as a world power in the decades to come," IEEE president Merrill W. Buckley Jr. challenged the U.S. presidential candidates to reveal their plans to foster the growth of new technologies and the electronics industry so as to keep the United States competitive in the global marketplace.

Buckley, speaking at an April 13 press conference in Washington, D.C., organized by IEEE U.S. Activities, pointed out that electronics, with one out of nine manufacturing jobs in the United States, is the country's largest manufacturing industry. One out of every 25 jobs is electronics-related, three times as many people are employed in the electronics field as work in the automotive industry, and nine times as many as in basic steel.

However, in the last two years, 150 000 jobs have been lost in U.S. electronics and 1.2 million jobs in U.S. manufacturing, Buckley said. And, according to a study by the U.S. Congress' Office of Technology Assessment, almost 40 percent of the estimated 342 000 defense engineering positions available in 1990 may no longer exist by 1995.

Raising the specter of the U.S. electronics industry going down "the same path as our dying automobile industry," Buckley made it clear that he regards the problem as essentially political. "We need a coherent national technology policy," he told the assembled journalists, which he more or less equated with a national industrial policy. "Other major economic powers use national policies to promote their industries and to be competitive. We should, too."

Among the technologies that he highlighted as worthy of emphasis by a national technology policy were flat-screen displays, high-definition television, supercomputers, and superconductivity.

Grants for precompetitive R&D

Some US $90 million in grants for promising precompetitive R&D projects was awarded by the U.S. Department of Commerce's Advanced Technology program. Digital image storage and decompression using fractals and creation of a hybrid superconducting logic system are among the 27 projects being funded.

The projects are in the fields of electronics, computing, high-temperature superconductivity, advanced materials, biotechnology, and special optics for focusing X-ray and neutron beams. More than 80 large and small companies, universities, research institutions, and consortia will be involved in projects supported by the grants.

Among the IEEE elect

The National Academy of Engineering elected 13 members of the IEEE among an overall total of 79 new members and seven foreign associates. They were honored for having made important contributions to engineering and for demonstrating an unusual degree of accomplishment in new and developing fields of technology.

In addition, nine IEEE members received the National Science Foundation's Faculty awards for Women in Science and Engineering. Exactly 100 female science and engineering professors were chosen for the awards, which each carry a prize of US $50 000 over a five-year period [THE INSTITUTE, May/June, p. 9].

Coming
in Spectrum

RISC AND THE SUPERCOMPUTER. Digital Equipment Corp. is filing a new, reduced-instruction-set computer (RISC) architecture, called Alpha, that the company says can last for the next 25 years. The first chip based on Alpha does 400 million instructions per second. Moreover, Digital is opening up this scalable design to supercomputer manufacturers.

FUZZY LOGIC IN JAPAN. Japan is far ahead of the rest of the world in fuzzy logic. Its citizens ride fully automated "fuzzy" subways, stay cool with "fuzzy" air-conditioners, and use "fuzzy" washing machines and "fuzzy" video cameras.

'OPTICAL' POLICE RADAR. Doppler-type police radars sometimes misidentify a speeder or even produce false readings. The answer may be new equipment based on recent developments in electro-optics (lasers), signal processing, very large-scale IC (VLSI) technology, and video recording.

NO MORE GHOSTS. A voluntary standard for a television ghost-canceling reference signal is about to be selected in the United States. When broadcast along with the normal TV signal, the new signal will enable TV receivers to automatically cancel the multipath distortions common in terrestrial broadcasting.

SOFTWARE RELIABILITY. The term means different things to the developer, the tester, and the user. So a composite measure of this feature is being sought.

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